HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Master's thesis in Geography

Urban and human geography and spatial planning

Economic resilience of protected and conserved areas in South Africa

Marisofia Nurmi

2021

Supervisors: Enrico Di Minin and Hayley Clements

Maantieteen maisteriohjelma / Magisterprogram i geografi / Master's Programme in Geography

Matemaattis-luonnontieteellinen tiedekunta / Matematisk-naturvetenskapliga fakulteten / Faculty of Science

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

<table>
<tr><td colspan="2">Tiedekunta – Fakultet – Faculty

Faculty of Science</td><td colspan="2">Osasto – Institution – Department

Department of Geosciences and Geography</td></tr>
<tr><td colspan="4">Tekijä – Författare – Author

Marisofia Nurmi</td></tr>
<tr><td colspan="4">Tutkielman otsikko – Avhandlings titel – Title of thesis

Economic resilience of protected and conserved areas in South Africa</td></tr>
<tr><td colspan="4">Koulutusohjelma ja opintosuunta – Utbildningsprogram och studieinriktning – Programme and study track

Master's programme in geography, Human geography</td></tr>
<tr><td>Tutkielman taso – Avhandlings nivå – Level of the thesis

Master's thesis, 30 credits</td><td colspan="2">Aika – Datum – Date

November 2021</td><td>Sivumäärä – Sidoantal – Number of pages

68 + 1 appendix</td></tr>
</table>

Tiivistelmä – Referat – Abstract

Globally, there is a constant shortfall of financial resources in conservation, which has partially been supplemented by combining conservation and conservation-compatible businesses. Many protected and conserved areas in sub-Saharan Africa are largely funded by revenues generated within the area, mainly through ecotourism. While ecotourism revenues are bringing in money into the system, dependency on this single type of revenue source is making conservation areas – or even the whole protected area system – vulnerable to changes in visitor numbers, which are prone to different political or socio-economic disturbances (such as conflicts, economic recession, and epidemics). A sudden substantial decrease in revenues or increase in costs may threaten the existence, extent, and quality of conservation areas in terms of biodiversity conservation. Collecting and analysing economic information on protected and conserved areas can help investigate their long-term sustainability and resilience to financial threats, such as the COVID-19 pandemic and related economic outcomes.

In this thesis, I assess how conservation costs and revenues vary between different types of protected and conserved areas, how financially self-sufficient they are, and how economically resilient these areas may be in the face of global changes. The analysis is based on financial data from different types of protected and conserved areas in South Africa: state-owned national parks (South African National Parks, later SANParks), provincial parks (Ezemvelo KwaZulu-Natal Wildlife, later Ezemvelo) and private conserved areas. With the use of simulation modelling and resilience theory, I discuss how potential economic resilience varies between protected areas.

The findings indicate that there are significant differences in the cost-revenue structure of different kinds of protected and conserved areas, and especially between public and private. Ezemvelo receives most of its funds from the provincial government, whereas SANParks covers the majority of its costs from tourism revenues. Private game reserves again need to cover their costs independently. According to the findings, size is an important attribute to predict the per hectare net income and running costs of public protected areas but has no significant influence on those of private game reserves. For public protected areas, the running costs per hectare are significantly higher for protected areas less than 1000 hectares.

Based on the economic modelling and resilience theory, I concluded that private game reserves are generally financially more viable, but their vulnerability lies in their lack of embeddedness within a larger system (e.g., a conservation organization) that could support them during difficult times and require and encourage a long-term commitment to conservation. The economic resilience of public protected areas is more closely tied to the political atmosphere regarding conservation funding: self-generated revenues form only a part of the budgets of public protected areas. In addition, protected areas which have large fixed costs and depend on high tourism revenues are likely to be less economically resilient. Because of the higher running costs and resultant sensitivity of net income to changes in costs and revenues, parks that are home to the "Big Five" species (lion, leopard, rhino, elephant and buffalo) are in a more vulnerable position in the face of disturbances, as the pandemic.

To address the threats that upcoming socio-economic disturbances pose to the funding base of protected and conserved areas, more focus should be given to the economic resilience of these areas, especially in countries and occasions where the areas rely on self-generated revenues.

Avainsanat – Nyckelord – Keywords

conservation geography, economic resilience, protected and conserved areas, South Africa

Säilytyspaikka – Förvaringställe – Where deposited

University of Helsinki electronic theses library E-thesis/HELDA

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Tiedekunta – Fakultet – Faculty	Osasto – Institution – Department
Matemaattis-luonnontieteellinen tiedekunta	Geotieteiden ja maantieteen osasto

Tekijä – Författare – Author

Marisofia Nurmi

Tutkielman otsikko – Avhandlings titel – Title of thesis

Suojelualueiden taloudellinen resilienssi Etelä-Afrikassa

Koulutusohjelma ja opintosuunta – Utbildningsprogram och studieinriktning – Programme and study track

Maantieteen maisteriohjelma, Ihmismaantiede

Tutkielman taso – Avhandlings nivå – Level of the thesis	Aika – Datum – Date	Sivumäärä – Sidoantal – Number of pages
Maisterintutkielma, 30 opintopistettä	Marraskuu 2021	68 + 1 liite

Tiivistelmä – Referat – Abstract

Luonnonsuojelussa on globaalisti jatkuva pula taloudellisista resursseista, mitä on osittain pyritty täydentämään suojelun kanssa yhteensovitettavilla liiketoimintamalleilla. Saharan eteläpuolisessa Afrikassa suojelualueita rahoitetaan suurelta osin alueella tuotetuin varoin, pääasiassa ekoturismin tuotoilla. Vaikka ekoturismi tuo suojeluun tärkeitä resursseja, riippuvuus tästä yhdestä tulonlähteestä uhkaa tehdä suojelualueista - tai jopa koko suojelutoiminnasta – haavoittuvaisia muutoksille vierailijamäärissä, jotka ovat puolestaan alttiita poliittisille ja sosio-ekonomisille häiriöille (kuten konflikteille, taloudelliselle lamalle tai epidemioille). Merkittävä suojelualueen tulojen menetys tai menojen kasvu taas voi pahimmillaan uhata suojelualueen olemassaoloa, laajuutta ja laatua biodiversiteetin suojelun näkökulmasta. Suojelualueiden taloudellisen tiedon kerääminen ja analysoiminen voi auttaa ymmärtämään ja parantamaan alueiden pitkäkestoista kestävyyttä ja resilienssiä taloudellisia uhkia, kuten COVID-19 -pandemiaa ja sitä seuranneita taloudellisia vaikutuksia, vastaan.

Tutkielmassa tarkastelen, kuinka suojelun menot ja tulot vaihtelevat eri tyyppisten suojelualueiden välillä, kuinka taloudellisesti itsenäisesti suojelualueet voivat toimia, ja kuinka resilienttejä nämä alueet ovat globaalien muutosten edessä. Analyysi perustuu taloudelliseen dataan erityyppisiltä suojelualueilta Etelä-Afrikassa: kansallispuistoista (South African National Parks, myöhemmin SANParks), KwaZulu-Natal -provinssin puistoista (Ezemvelo KwaZulu-Natal wildlife, myöhemmin Ezemvelo) ja yksityisiltä suojelualueilta. Simulaatiomallinnuksen ja resilienssiteorian avulla tarkastelen, miten potentiaalinen taloudellinen resilienssi vaihtelee erilaisten suojelualueiden välillä.

Tulosten perusteella suojelualueiden tulo-meno-rakenne vaihtelee huomattavasti eri suojelualuetyyppien välillä, erityisesti julkisten ja yksityisten suojelualueiden välillä. Ezemvelon budjetti koostuu pääosin provinsiaalisen hallituksen myöntämästä rahoituksesta, kun taas SANParks kattaa suurimman osan menoistaan turismituloilla. Yksityisten suojelualueiden tulee kattaa menonsa itsenäisesti. Tutkielmani tulokset osoittavat, että suojelualueen koko määrittää merkittävästi hehtaarikohtaista nettotuloa ja juoksevia menoja julkisilla suojelualueilla, mutta sillä ei ole merkittävää vaikutusta yksityisillä suojelualueilla. Julkisten suojelualueiden osalta hehtaarikohtaiset juoksevat kulut kasvavat huomattavasti pienillä suojelualueilla, jotka ovat kooltaan alle 1000 hehtaaria.

Taloudellisiin malleihin ja resilienssiteoriaan kytkeytyvän pohdinnan perusteella päädyin analyysissä siihen, että yksityisillä suojelualueilla menee yleisesti taloudellisesti paremmin, mutta niiden taloudellinen (ja suojelutoiminnan jatkuvuuden) haavoittuvuus piilee siinä, ettei niiden takana ole laajempaa järjestelmää: järjestelmää, joka auttaisi vaikeiden aikojen yli, vaatisi ja rohkaisisi pitkäaikaiseen luonnonsuojeluun sitoutumiseen. Julkisten suojelualueiden taloudellinen kestävyys on enemmän sidoksissa suojelurahoitusta koskevaan poliittiseen ilmapiiriin, sillä itse kerrytetyt tulot muodostavat vain osan julkisten suojelualueiden budjetista. Suojelualueet, joilla on suuret kiinteät kustannukset ja jotka ovat riippuvaisia suurista matkailutuloista, ovat yleensä taloudellisesti vähemmän resilienttejä. Korkeampien juoksevien kulujen ja nettotulojen muutosherkkyyden vuoksi suojelualueet, joilla tavataan “suurta viisikkoa” (leijona, leopardi, sarvikuono, norsu ja puhveli) ovat haavoittuvammassa asemassa kohdatessaan esimerkiksi pandemian kaltaisia, taloutta ravisuttavia häiriöitä.

Jotta voidaan puuttua uhkiin, joita tulevat sosioekonomiset häiriöt aiheuttavat suojelualueiden rahoituspohjalle, näiden alueiden taloudelliseen kestävyyteen olisi kiinnitettävä enemmän huomiota, erityisesti maissa ja niissä tilanteissa, joissa alueet ovat riippuvaisia suojelualueella itse tuottavista tuloista.

Avainsanat – Nyckelord – Keywords
suojelumaantiede, taloudellinen resilienssi, suojelualueet, Etelä-Afrikka

Säilytyspaikka – Förvaringställe – Where deposited

Helsingin yliopiston elektronisten aineistojen kirjasto E-thesis/HELDA

Table of contents

List of figures

List of tables

I. Introduction

1.1 Context

Protected areas are the main strategy to conserve nature and halt biodiversity loss (Geldmann et al., 2020; Palomo et al., 2014; Watson et al., 2014), which is considered one of the most severe environmental problems of our time (Ceballos et al., 2015). Conservation areas also play an important role in providing both material and non-material ecosystem services, some of which are essential to human health and security (Biggs et al., 2012). They provide cultural services, such as sense of place, recreation possibilities, and cultural meanings, which enhance human wellbeing (see, for example, Hausmann et al., 2016).

Establishing and managing protected areas requires financial resources. There is a constant shortfall in financial resources for conservation globally (Bruner et al., 2004; McCarthy et al., 2012). Current resources seem to be inadequate even to manage existing protected areas, let alone to expand the network of protected areas to meet urgent conservation targets (Bruner et al., 2004; Emerton et al., 2006; McCarthy et al., 2012). According to calculations made by McCarthy et al. (2012), there was a funding shortfall of 1-1.7 billion U.S. dollars per year, to adequately manage existing protected areas in the developing world. Managing an expanded network of protected areas (based on Aichi 2020 conservation targets) would total four billion dollars in the developing world (McCarthy et al., 2012). This cost is likely to be substantially higher now, a decade later, and is expected to rise in the future, as the biodiversity continues to decline and the conservation targets have not been met (Drechsler et al., 2011; McCarthy et al., 2012).

The lack of resources for sound management may lead to “paper parks”; protected areas that are officially protected but lack any action towards actually conserving the area for biodiversity (Di Minin and Toivonen, 2015). The results of a study by Geldmann, Manica, Burgess, Coad and Balmford (2020) indicate that it may be more effective to have less but well-managed protected areas than more but poorly managed areas. Poor management lowers the effectiveness of protected areas undermining their potential both in achieving conservation goals and in providing ecosystem services (Geldmann et al., 2020). The funding shortage existed already before the COVID-19 pandemic, and after the outbreak, the situation has become even more threatening (T. Cumming et al., 2021; Lindsey et al., 2020).

In economic terms, there is a market failure: the benefits of protected areas are hard to monetarize and thus, their value is underestimated (Dixon & Sherman, 1991). Dixon and Sherman (1991) suggest that the market failure stems from the lack of effective markets on conservation and the public good characteristic of protected areas. Another inconsistency in conservation financing is that action and investments are undertaken too late. Conservation policies and investments tend to focus on species that are already endangered, even though a proactive approach to species conservation (conserving species that are not yet endangered) could save financial resources compared to more expensive acts which need to be undertaken to bring endangered species back to sustainable population levels (Drechsler et al., 2011).

Ecotourism and other wildlife-based activities, such as hunting and wildlife trade, are ways to generate revenues from conservation. These activities, as well as publicly funded conservation programs, also offer a way for private landowners and communities to contribute to conservation while getting economic benefits from it. In some countries, the network of private and community-owned protected and conserved areas has expanded to partially complement the network of state-owned protected areas (see Cortés-Capano, 2021).

Collecting and analysing economic information on protected and conserved areas can help investigate their long-term sustainability and resilience to financial threats, such as the COVID-19 pandemic and related economic outcomes. Analysing these data is especially important when identifying existing structural and systemic financial constraints and weaknesses of protected and conserved areas. This is imperative when it comes to private conservation areas, as financial incentives may be the reason behind establishing a conservation area. Including economic costs and benefits in conservation assessments is also helpful in guiding conservation investment to achieve the highest return, given limited resources (Di Minin et al., 2013, 2017; Naidoo & Adamowicz, 2005; Naidoo et al., 2006). This means that more biological diversity can be conserved with the same financial resources. Despite the relevance of research on the economic sustainability of protected areas, these studies are often missing in conservation science literature.

South Africa has 8% of its land under formal conservation, of which 2% is privately owned. In addition, there are many informal private conservation areas that are not legally recognised but nevertheless contribute to nature conservation. The extent of all privately conserved areas (formally and informally protected) is estimated to be around double (17%) that of state-owned protected areas (De Vos et al., 2019).

In South Africa, as in many other sub-Saharan countries, the costs of managing both state and private protected areas are covered to a large extent through conservation businesses, mainly ecotourism (state and private) and hunting (private). Ecotourism and trophy and biltong hunting are the most important income sources in conservation areas in sub-Saharan Africa (Di Minin et. al, 2016; Lindsey et al., 2021 and Taylor et al., 2016). Frank et al. (2005) see ecotourism and trophy hunting as the "only ways of making large-scale conservation possible". Live sales of wild animals and plants are also a way of generating revenues from a conservation area (African Leadership University School of Wildlife Conservation, 2020). In sub-Saharan Africa, ecotourism has a substantial effect on national GDP (African Leadership University School of Wildlife Conservation, 2020). In South Africa, the revenue generated from ecotourism is roughly as much as revenue from farming, forestry, and fisheries combined (G. S. Cumming et al., 2015).

Conservation areas face socio-economic and ecological disturbances that threaten their ability to reach conservation goals or even their existence, in some instances by impacting their financial viability (T. Cumming et al., 2021). These disturbances are becoming more common and intense as a result of increasing anthropogenic pressures (Geldmann et al., 2020), global connectivity (Lindsey et al., 2020), and climate change (Clements et al., 2020; Geldmann et al., 2020; Johnson et al., 2016).

Ecological and socio-economic disturbances can be abrupt events (epidemics, natural hazards) or slowly evolving changes in the system (climate change, politics, economic recessions). These disturbances and following threats can either directly cause damage to the biodiversity in the area (e.g. wildfires, loss of food due to drought, poaching) or indirectly by affecting negatively the budgets of conservation areas (e.g. increased management or damage costs, loss of revenues). Economic losses of protected and conserved areas lower the available resources and thus the conservation capacity. At worst, it can lead to “protected area downgrading, downsizing and/or degazettement”, referred to as PADDD in conservation literature (Mascia & Pailler, 2011).

Disturbances in socio-economic systems can be more threatening to conservation than ecological disturbances. Cumming et al. (2015) concluded that social and economic processes dominantly shape the resilience of protected areas even over ecological processes at broader scales. At finer scales, ecological processes are still directly relevant to protected areas. Socio-economic disturbances include conflicts and poaching, changes in national and international legislation, economic recession, and epidemics. Most of these socio-economic disturbances affect protected and conserved areas indirectly, through changes in the political situation and legislation (e.g. political instability that reduces international visitation) or changes in financial resources available for conservation. Unexpected events, changes, and disturbances may impact the budgets of a conservation area by a decrease in revenues and other funding, or by an increase in conservation costs.

1.2 Literature review

A literature review was carried out using the collections of Web of Science and the search results of Google Scholar. The literature review focused on studies on the economics of protected and conserved areas. First, the costs and revenues of managing protected areas were identified based on the literature (chapter 1.2.1). Then I identified the underlying factors which may explain the variation of revenues and costs, based on the earlier research (chapter 1.2.2). The results of the literature review are summarized in Table 1. Search results were geographically defined to mostly cover studies carried out in sub-Saharan Africa and at the global level because the funding sources and items of expenses vary depending on the societal and biophysical settings (see, for example, De Vos et al., 2016).

Table 1. Costs and revenues of protected and conserved areas and their variation based on underlying factors. Public funding is in brackets as it is not a conventional revenue source, but important source of funding for public protected areas.

Type of costs/revenues	**Economic variables**	**Background variables** Factors that explain the variation (higher costs per area unit)
Recurrent management costs	- on-site administration and marketing - employee-related costs (salaries for park management, lodge staff, guides and other service providers) - ecological monitoring and research - game management (veterinary costs, food) - game purchases - permits and licenses - maintenance and operating costs of the lodge(s) (food and beverages, cleaning etc.) - maintenance of the park (maintaining roads and fences, alien vegetation control, anti-poaching units, etc.)	- High species endemism or threat level (Moore et al., 2004) - Small reserve size (economies of scale) (Adams et al., 2012; Balmford et al., 2003; Frazee et al., 2003) - local socio-economic context (on global scale comparisons: General National Income, Purchasing Power Parity) (Balmford et al., 2003) - Habitat and ecoregion type (Frazee et al., 2003)
Investment and asset-related costs	- New infrastructure - vehicles and equipment - Interests and loan repaymentsl	
System-wide costs	- Organization-wide administration and marketing - land acquisition and establishment costs of new protected areas	
Opportunity cost	- compensation to the local people to offset opportunity costs, such as lack of access to grazing land, and possible damages, such as from crop-raiding elephants, predation of cattle	- Absence of fences (Fencing reduces damage costs and human-wildlife conflicts, see for example Packer et al., 2013) - Conflicting interest with other (high value) land uses (Frazee et al., 2003)
Tourism revenues	- Non-consumptive ecotourism (accommodation, entrance fees, activities, restaurants, retail etc.)	- Visitor numbers: location, ecology, infrastructure, affordability, presence of charismatic species (see Baum et al., 2017a; De Vos et al., 2016; Di Minin et al., 2013; Hausmann et al., 2018) - Legislation (Di Minin et al., 2016) - Economic recession - Epidemics, human and wildlife (De Vos et al., 2016; Gössling et al., 2020; Lindsey et al., 2020)
Other revenues	- Trophy/game hunting - Game/plant live sales - Game meat sales - Donations (international aid, NGOs, private) - Farming e.g. livestock or cash crops - Renting / leasing land	
(Public funding)	Funding from the government, tax reductions etc.	Politics, legislation

1.2.1 Economics of protected and conserved areas

Reid (2015) defines conservation economics 'as the use of economics to understand the costs and benefits of sustaining natural ecosystems'. The economics of conservation areas applies conservation economics to the context of protected and conserved areas (see, for example, Dixon & Sherman, 1991; Naidoo et al., 2006; Naidoo & Ricketts, 2006).

A broad perspective to conservation economics takes into account the social benefits of protected and conserved areas, which can be measured by assessing the value of ecosystem services that the area provides or could potentially provide (see, for example, Hausmann et al., 2016; Naidoo & Ricketts, 2006). At a broad scale, the economic analysis may also include the analysis of economic spill-over, which can happen for example through increased tourism activities around a protected area (Chidakel et al., 2021). If the value of the protected area is assessed, then these social benefits and leakage effects should be considered.

As opposed to public economic analysis, which considers all different benefits, private economic analysis does not account for social benefits but concentrates on direct benefits that can be monetarized (Dixon & Sherman, 1991). The scope of this thesis is a local private economic analysis approach, which only concentrate on revenues and costs that are generated within protected and conserved areas. This perspective provides insights on the degree to which protected and conserved areas can operate with financial independence (i.e., without government funding), how the conservation costs and revenues vary between different types of protected and conserved areas and how economically resilient these areas may be in the face of global change.

In this local private economic analysis, the economics of protected and conserved areas consists of the costs and revenues related to establishing and managing protected areas. From a literature review, I identified and adapted the following costs categories: recurrent management costs, investment and asset-related costs, and system-wide costs. Revenues and funding were categorised into tourism revenues, other revenues and public funding (Table 1) (Bruner et al., 2004; Dixon & Sherman, 1991; Lindsey et al., 2020).

Recurrent management costs refer to annual management costs which take place at the protected area level. The second cost category is the investment and asset-related costs, which are one-off costs that relate to building new infrastructure or other long-term investments. The third category refers to system-wide expenses incurred by an organization supporting a network of protected areas, including the establishment costs of creating a new conserved area, and all general services which go beyond the borders of protected areas (financial and HR services etc.). In addition to the actual costs of establishing and managing protected areas, are the opportunity costs: giving up the resources and income that would have been produced if alternative land use options had been chosen (Naidoo et al., 2006).

At the protected area level, conservation area managers (private or public) are mostly concerned with recurrent management costs, including site-level administration, salaries, vehicles, operations, and development projects and monitoring and evaluation costs (Bruner et al., 2004). The system-wide costs do not affect the reserve-level economics and do not apply to private conservation areas, which are not part of a larger organization and network of protected areas. System-wide costs are therefore only considered in the context of public protected areas. Opportunity costs and damage costs are costs from compensating lost opportunities and possible damages for local people. This is only relevant in the private economic analysis if the conservation area is obligated to pay any compensation to local people. However, the opportunity costs may affect decisions related to the continuation of conservation in the area when it is possible to change the land use to something else. The level and time frame of commitment to conservation in privately conserved areas depend on the type of stewardship agreement (see chapter 3.1). In general, the more regulated and long-term commitment there is, the more other benefits (tax deductions, etc.) are provided. On the other hand, lower regulation enables landowners to combine multiple conservation compatible land uses, such as livestock grazing and ecotourism, and thus lowering opportunity costs of conservation (South African National Biodiversity, 2017; Taylor et al., 2020).

On the revenue side, the first category is tourism revenues which refer to all revenues retrieved from tourism-related activities: entrance fees, tours, accommodation and restaurants, retail and so on. Other revenues include trophy hunting and natural resources, and revenues from conservation-compatible land use, such as small-scale farming (Clements et al., 2016, Fischer et al., 2008). The third category is not an actual revenue but a funding source for public protected areas: public funding or other financial incentive provided by the state or provincial government.

1.2.2 Spatial variation of costs and revenues

According to the literature, the size of a protected area affects its annual management costs per area unit. As the area increases, management costs per hectare generally decrease (Bruner et al., 2004; Frazee et al., 2003). Frazee et al. (2003) provide an interesting regional assessment of management costs of protected areas. They assessed unit management costs based on physical and biological attributes in a biodiversity hotspot: Cape Floristic Region in South Africa. They found that the size of the protected area was the most important biophysical attribute that affected unit management costs. Their finding validates the assumption of the "economies of scale" phenomenon, which in this context means that as the size of the protected area increases, the management costs per hectare decrease. According to their findings, conservation areas under 600 hectares have substantially bigger management costs per hectare. On top of being expensive to manage in comparison with larger areas, smaller protected areas also fail to support species that require extensive habitats (Frazee et al., 2003). Other similar results emerge from a study that estimated stewardship costs per hectare in the Northern Territory in Australia, in which the management costs per hectare increased exponentially for property areas below 1000 hectares (Adams et al., 2012).

Moore et al. (2004) concluded in their Africa-wide research that the presence of endemic and threatened species increases substantially the management costs. This variation is largely explained by more extensive management actions needed to protect endemic and threatened species. Invasive alien species also increase the management costs in areas where they pose threat to the local species. The clearing of invasive plants for example may become very costly (Versveld et al., 1998)

According to the findings by Moore et al. (2004), the costs of effectively managing a protected area vary a lot between ecoregions, but at the same time conserving only the “cheaper” areas would give a poor representation of conserved biodiversity. For example, conserving desert habitats is less expensive per area unit than coastal forests (Moore et al., 2004). Frazee et al. (2003) also identified habitat class as an important attribute that influences the management costs. In the study area of Cape Floristic Region in South Africa, they found out that the management costs were higher in the mesic lowland areas than in the montane habitats, such as dry mountain fynbos (Frazee et al., 2003).

In the South African context, the income from nature-based tourism is a very important source of revenue for conservation areas and thus studies on factors that affect visitation numbers can be relevant when considering the spatial variation of conservation budgets. There are some studies where changes in protected and conserved area visitor numbers have been modelled using a set of ecological, spatial, and economic predictor variables (Baum et al., 2017; De Vos et al., 2016). Baum, Cumming, and De Vos (2017) analysed the spatial variation of visitation rates between different private conservation areas in the Western Cape, South Africa. They found out that this variation could be explained largely by species presence, availability of infrastructure and affordability. Visitation numbers and the income from tourism were positively affected by the number of facilities and so-called “Big Five” species (lion, leopard, rhino, elephant and buffalo). On the other hand, lower accommodation prices attracted some tourists. These results are aligned with another very similar study that concerned national parks in South Africa (De Vos et al., 2016). When it comes to national parks, a bigger proportion of variation in tourism numbers could be explained with contextual factors than in private protected areas, which may be explained with them being more homogenous in terms of management strategies and models than private conservation areas (Baum et al., 2017).

The “Big Five” species have been identified as an important pull factor for international tourists in South Africa (Lindsey et al., 2007). Large and potentially dangerous mammals attract visitors and therefore they can be seen as “money generators” from an ecotourism perspective. However, having large and potentially dangerous mammals is also expensive as it is requires electrified fences and other safety infrastructure. There is also an increased risk of poaching activities, which create additional costs and risks. Especially rhinoceros have been targets of extensive poaching in South Africa (Di Minin et al., 2015). Antipoaching units need to be maintained and there are additional security and other risks related to losing charismatic species. Both revenues and management costs are thus generally larger for protected areas that are home to the Big Five species. Thus, it remains unclear whether the protected areas economically benefit from having Big Five species.

Which factor is the most important varies depending on the visitor: according to De Vos et al. (2016) affordability was the most important factor for overnight visitors to explain their choice of protected area, whereas aesthetic cultural services (lookout points, waterfalls etc.) were the most important consideration for day visitors. Large-bodied mammals, especially the Big Five species, attract international tourists and less experienced travellers (Di Minin et al., 2013; Lindsey et al., 2007). Local and more experienced travellers and wildlife viewers are more interested in the diversity of other biodiversity groups, such as birds and vegetation (Di Minin et al., 2013; Hausmann et al., 2018; Lindsey et al., 2007). The presence of rare species and beautiful scenery were also more important pull factors for local and experienced travellers (Lindsey et al., 2007).

Outside Africa, there are also a few studies about the factors which affect visitation rates. In the Finnish context, Neuvonen et al. (2010) found that supply-side, referring to the attractions provided by a national park such as opportunities for recreation, path network extent and diversity of biotopes, were more important factors than the "demand-side" (proximity to population clusters, accessibility). However, the results depended on the spatial scale: for Southern Finland where the population is concentrated, the accessibility of national parks and their proximity to population centres had a significant influence on the visitation rates. This can be explained by the different roles of national parks in different parts of Finland: the easily accessible national parks in Southern Finland, close to population centres serve day trip recreation opportunities for locals. The more remote national parks in Northern Finland facilitate multi-day trips and most of the visitors are either staying overnight in the national park or proximate accommodation (Neuvonen et al., 2010).

Some of these pull factors are conflicting, especially in areas where the charismatic species may also be dangerous for people. For example, affordability and the presence of the Big Five species, or the recreational possibilities and the presence of potentially dangerous mammals are usually incompatible features. Similarly, more remote protected and conserved areas may offer experiences in the real wilderness but at the same time are harder and more expensive to access than close-by protected areas, as in the case presented by Neuvonen et al. (2010).

These different values between visitor profiles have been researched also from the perspective of the managers of protected areas and their financial objectives. Clements et al., (2016) identifies and presents four different business models of private conservation areas in South Africa based on their features and owner's objectives and target audience. According to their findings, the "high-end" business model which applied to large areas with many charismatic species, high diversity of other species and luxury services, was the most profitable whereas hunting-focused reserves and "low-end" reserves with few game species and cheap accommodation were the least profitable (Clements et al., 2016).

1.3 Research problem

Many conservation areas, including state-owned protected areas in sub-Saharan Africa, rely largely on the income generated in the area to fund their conservation activities. Ecotourism and other conservation businesses generate money for conservation, but these revenue sources have also made some conservation areas, or even whole protected area systems, dependent on ecotourism as their only or main source of income. In 2018, 84% of the budget of South African National Parks (SANParks) came from tourist-related spending (Lindsey et al., 2020). Dependence on this single type of revenue source risks making conservation areas vulnerable to changes in visitor numbers. The number of visitors is prone to different political or socio-economic disturbances, such as conflicts and terrorism, economic recession, and epidemics. A decrease in revenues or an increase in costs leads to budget shortfalls. If revenues decrease substantially, the extent, existence, and quality of conservation areas in terms of biodiversity conservation are under threat (see, Geldmann et al., 2020).

For private land conservation areas in some countries, particularly in southern Africa, the ability to make a livelihood from wildlife-based activities is one of the reasons for landowners to conserve their land (Child et al., 2012; Clements et al., 2016). Vulnerability to budget changes through a decrease in income or an increase in costs is likely to apply especially to those private protected areas that do not have diverse income sources, and those with large fixed costs. Income from tourism may be the only source of income for the owner of a conservation area, in which case the amount of tourism revenues determines the continuity of conservation in that area. Many private game reserves in South Africa have large, fixed costs due to the stocking of large animals and consequently, the need for fence and waterhole maintenance and additional megaherbivore or large predator feeding in times of drought. These areas generally have higher economic incentives, and conservation is more business-like (Clements et al., 2016). Often these areas generate their revenues through high-end ecotourism, which adds additional running costs such as a large number of employees, the maintenance of lodges, roads and vehicles, and food (Clements et al., 2016). If a conservation area cannot absorb the stress caused by a disturbance, or adapt to the new conditions, the owner may have to find an alternative land use such as livestock farming or agriculture, and the future of conservation is at stake.

The COVID-19 pandemic is an extreme example of a disturbance that has posed severe challenges for some conservation areas or even nation-wide protected area systems in sub-Saharan Africa. Due to the restrictions arising from the COVID-19 pandemic, both international and domestic tourism sectors stagnated in 2020 and 2021, and a significant proportion of conservation revenues (if not all) disappeared. Lindsey et al. (2020) argue, that even though there are some positive environmental outcomes from COVID-19 mitigation strategies (such as reduced emissions and pollution and restrictions in unsustainable wildlife trade) these positive outcomes may remain temporary as people return to business as usual after restrictions ease. According to the authors, the environmental outcomes of COVID-19 in Africa are strongly negative because of lower conservation capacity, reduced funding, and increased threats to wildlife (Lindsey et al., 2020).

The large proportion of privately protected areas and the minor role of public funding in SANParks' budget make conservation actions in South Africa dependent on the income created by the conservation areas themselves. Tourism-reliant private conservation areas, whose owners have no other sources of income, are likely to be particularly vulnerable to disturbances. If the required economic realities are not met, what will happen to conservation areas?

1.4 Research objectives and questions

This thesis aims to build a better understanding of the economics of protected and conserved areas in South Africa. The research objective is to compare the cost-revenue structure of different types of protected and conserved areas and to discuss how the potential resilience varies between these areas. Protected and conserved areas are compared and assessed based on their size and management authority: state-owned parks managed by SANParks, provincial parks in KwaZulu-Natal (KZN) managed by provincial conservation authority Ezemvelo KZN Wildlife (Ezemvelo) and private game reserves. I also examine whether the economies of scale phenomenon applies to the economics of protected areas: are the per hectare running costs significantly higher for smaller protected and conserved areas than for larger ones?

I then take a closer look into Ezemvelo's protected areas and assess the differences in current and potential cost-revenue structure between protected areas that are home to all Big Five species (lion *Panthera leo*, leopard *Panthera pardus*, African bush elephant *Loxodonta africana*, black and white rhino *Diceros bicornis* and *Ceratotherium simum*, and African buffalo *Syncerus caffer caffer*) and those that are not.

This thesis aims to address the following research questions:

1. How do revenues, costs and net income vary between different kinds of protected and conserved areas
    a. at reserve level (SANParks, Ezemvelo and private)?
    b. at the organisational level (SANParks and Ezemvelo)?

2. What is the effect of the size of a protected or conserved area on its running costs and the net income per hectare? Does the "economies of scale" phenomenon apply to these areas?
3. How do provincial parks (managed by Ezemvelo) that are home to the Big Five species compare economically with parks which do not support these species?
4. How and why might potential economic resilience vary between the different types of protected areas?

II. Theoretical and conceptual framework

The thesis focuses on conservation economics including aspects of conservation geography and human geography. Conservation is not merely about ecology, but about people in interaction with the environment, their perceptions and values towards nature, and their ability to make sustainable choices. Based on the definition by Di Minin et al. (2021), quantitative conservation geography “combines aspects of human geography (i.e., people and their communities, cultures, and economies) and physical geography (i.e., the living nature across levels of ecological organization encompassing genetic diversity, species, and ecosystems)”.

2.1 Conservation areas and social-ecological systems

The IUCN (International Union for Conservation of Nature) provides the following definition for a *protected area*:

> “A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.” (IUCN definition, 2008)

Conservation areas are geographical areas that are at least partially managed for biodiversity conservation but are not necessarily formally protected. In the thesis, I use the term combination of protected and conserved areas, or “reserves”, to cover both formally defined and legally recognized protected areas and informal areas managed for conservation.

The IUCN definition for protected areas is important because it provides a global definition for protected areas which is used in international biodiversity conservation targets and assessments. The inclusion of cultural meanings and ecosystem services reveals a paradigm shift from purely and strictly nature-focused conservation and community-excluding conservation strategies towards more inclusive ways of conserving nature (Mace, 2014).

Protected areas were originally created to conserve iconic landscapes (Watson et al., 2014). In sub-Saharan Africa, the first conservation areas were established during colonial times to provide hunting grounds for white elites (Watson et al., 2014). It is important to acknowledge the historical settings under which conservation areas were originally created as there are still unsolved issues related to land tenure, lack of political legitimacy, and unfair distribution of conservation benefits and costs (Mackenzie, 2012).

The concept of a "protected area" has indeed evolved in history from separated and isolated units of conserved areas (the "island approach") towards more systematic conservation planning, where conservation networks and ecological corridors are created (Palomo et al. 2014). Furthermore, the focus has widened in the 2000s to the inclusion of ecosystem flows between the protected areas and their surroundings and taking into account the social aspects and societal effects of the protected area system (G. S. Cumming et al., 2015; Palomo et al., 2014). This social-ecological system approach is widely adopted but a relatively new paradigm in conservation.

Managing protected and conserved areas as social-ecological systems means considering them as dynamic systems that do not exist in isolation but interact with the surrounding landscapes, other protected areas, and the society (De Vos et al., 2019). Therefore, protected areas respond to changes in the landscapes, as well as changes in demands and interests from society. Indeed, as the meaning of protected areas has by far exceeded merely conservation values, the demands posed by society have extended to cover diverse ecological, social, and economic objectives: from climate change mitigation to supporting the livelihoods of local communities and boosting national economies (Watson et al., 2014). Protected areas are human constructs; institutions that compete with alternative non-compatible land uses such as new housing development (G. S. Cumming & Allen, 2017). As social-ecological systems, protected areas are prone to changes and disturbances in politics and economies, in addition to the direct ecological threats from natural disasters. Conservation and protected area vulnerabilities towards disturbances that impact financial viability are of interest in the thesis.

Social-ecological systems are one way to conceptualize human-nature interactions. However, in human geography, t*erritoire* is traditionally a more commonly used concept in studying human-nature interactions. In addition to the obvious emphasis on locality and place-making, the *territoire* as a concept has also a stronger focus on the agency of people: people are active actors in creating the place. Barreteau et al. (2016) discuss differences and similarities between the two concepts of social-ecological system and *territoire,* aiming to bring these together and enabling a deeper understanding of these dynamics. *Territoire* brings new angles to the discussion, such as power dynamics and sense of place. These are extremely important aspects in conservation and especially in formerly colonised countries, places where there are issues with land tenures or otherwise high inequality levels. My perspective in this thesis is more on the management side of protected areas and the economic resilience of the system. From this point of view, I find the social-ecological system a more useful concept but recognise the need for future research taking a more social approach with a focus on individual agencies and power dynamics.

2.2 Resilience

Resilience is a concept used to represent the system's capability to operate while facing disturbances. The term has its roots in ecology but during the last decades, it has dispersed into other academic disciplines and also into public and political discourse (Carpenter et al., 2001; Holling, 1973; Kurikka, 2021 and Martin & Sunley, 2015). Carpenter et al. (2001) identify three properties of resilience, which have later developed into a widely used definition for resilience. The different properties are: 1) the amount of change the system can tolerate staying within the same "domain of attraction" (*engineering resilience*), 2) the system's capability to absorb stress and to self-organise (*ecological resilience*), and 3) the system's capacity to learn and adapt (*adaptive capacity*) (Carpenter et al., 2001).

Resilience represents long-term persistence. However, resilience should not be mixed with resistance, as it is only one aspect of resilience. Resistance is the capability of a system to remain unchanged, but a resilient system can reorganize itself or learn to adapt as a response to a disturbance. The second and third properties in Carpenter's definition highlight the endogenous changes in the system and its adaptivity.

Capability to self-organise means the systems' ability to endogenously reorganize themselves, for example through networks and innovative problem-solving. When it comes to the resilience of conservation areas, this capability to self-organisation could be connected to regulations and policies and the existence of collaborative and supportive networks. Adaptive capacity on the other hand reflects the system's ability to learn from disturbances and to cope with change (Carpenter et al., 2001). As Kurikka (2021) reminds, in the context of regional economic resilience, shocks that heavily impact a local economy can lead to reorganisation and even better and more resilient outcomes, as the shock breaks old structures that may have not been working that well.

Cumming and Allen (2017) further develop the definition as an "ability of a system to maintain its identity". When it comes to protected area resilience, the core of protected areas' identity is conserving nature. Thus, the ecological resilience of a protected area is linked to its ability to maintain its mission to "support long-term persistence of populations, species and communities of a wide range of organisms as well as related abiotic ecosystem elements and processes -- and ecosystem services." (G. S. Cumming et al., 2015).

System resilience is a complex concept. Whether the system is perceived as resilient or not usually depends on the scale and perspective. Social-ecological systems may be resilient on one scale for some elements in the system but not for others. For example, it is not possible to increase the resilience of all ecosystem services that the system provides (Biggs et al., 2012). Because the resilience of a system can differ between subsystems and system elements, it is important to define explicitly, what is a) the system for which resilience is examined (Resilience of what?) and b) the possible threat(s) that the system faces that are under consideration (Resilience to what?) (Carpenter et al., 2001). In the thesis, I focus on the economic resilience of individual conservation areas defined as their ability to maintain financial viability and thus, fund their conservation area management.

Considering the socio-economic perspective to protected area resilience that I have in my thesis; it is relevant to think which factors could make some conservation areas more resilient than others. Resilient systems have a variety of strategies to do the same thing. Response diversity and functional redundancy are important in building resilience, as they provide options to respond to and cope with change (Chidakel et al., 2020). Response diversity means the variety of different ways that the system elements or actors respond to disturbances (Biggs et al., 2012). Functional redundancy refers to the capability of system elements to substitute for each other. In biotic systems, genetic diversity and biodiversity build up ecosystem resilience usually through both functional redundancy and response diversity. In the context of conservation area resilience, the diversity of income sources would be one key element of functional redundancy. According to Clements, Biggs, and Cumming (2020), strategies to build protected and conserved area resilience would mean diversifying revenue streams and creating appropriate financial instruments.

III. Study area

3.1 Protected and conserved areas in South Africa

In South Africa, protected areas are protected in terms of the Protected Areas Act (2003). This network of formally protected areas consists of both public and private protected areas. Public protected areas include national parks managed by the state-led conservation authority SANParks (South African National Parks) and provincially managed nature reserves. In the thesis, I concentrate on provincial protected areas managed by KwaZulu-Natal's provincial conservation agency, Ezemvelo (Ezemvelo KZN wildlife). Ezemvelo is a governmental agency responsible for directing nature conservation and protected areas within KwaZulu-Natal province in eastern South Africa. It manages provincial parks and other protected areas in the province (KwaZulu-Natal Nature Conservation Management Act No.9 of 1997). I also include publicly available data for SANParks, who are responsible for managing 22 National Parks in South Africa.

Along with the widened management perspective of formally protected areas, there is an increasing interest in finding ways to conserve nature outside of officially protected areas. Conservation and biodiversity agreements are contracts where communities or private landowners are provided with certain financial or other tangible benefits in return for conservation actions. These agreements aim to provide direct incentives for communities and private landowners to contribute to nature conservation, and also to address the common misalignment of conservation costs and benefits (see, Niesten et al., 2010; South African National Biodiversity, 2017)

Private protected and conserved areas in South Africa are divided into three types, depending on their legal status: Private Nature Reserves (legally gazetted), Biodiversity Agreements (legally binding contract but not gazetted), and "Conservation areas" or "Conservancies" (not legally recognized) (Cadman, 2010 p.71 & Clements et al., 2016 p.110). In addition to public and privately-owned conservation areas, some of the protected areas have "mixed" ownership and management system. These areas are owned (at least partially) by communities or private landowners, but have similar legal status as state-owned nature reserves

(Cadman, 2010 p.74). Some private and community-owned conservation areas are governed via biodiversity stewardship programmes (South African National Biodiversity, 2017).

Different agreement types define the amount of regulation and landowner commitment, but also the number of incentives provided by conservation authorities or the government (see Cadman, 2010). Nature Reserves and Protected areas are the most strictly regulated while receiving also more incentives. On the other end are the informal conservation areas, which are less regulated but do not receive any public benefits.

As the thesis focuses on the economic analysis of protected and conserved areas at the reserve level, it is important to note that national and provincial protected areas are part of wider park networks managed by organizations (eg SANParks and Ezemvelo) and these parks do not operate in isolation. Financial resources are therefore allocated into different reserves, the strategy being that those reserves generating more revenue fund the more remote or otherwise costly protected areas (see, for example, Augrabies Management Plan 2012). This applies to public protected areas (SANParks and Ezemvelo) but not the private reserves.

3.2 Study area

The analysis is implemented in a South African context where good quality data from a set of conservation areas is available. A lot of conservation-related research is also done in South Africa, which makes it easier to connect and compare results with previous literature (e.g. Baum et al., 2017; Clements et al., 2016; De Vos et al., 2019; Frazee et al., 2003; Hausmann et al., 2017; Lindsey et al., 2007; Taylor et al., 2020). The South African context is especially interesting because of the exceptionally rich biodiversity and long conservation history on both state and private land (see Child, 2004). Conservation has turned into a viable land-use when demand for wildlife-based tourism increased and because of enabling policies that, for example, allowed the ownership of wildlife (see, for example, Child, 2004). In South Africa, 79% of the land is privately owned and the role of private land conservation areas in biodiversity conservation is recognised as significant (Clements et al., 2016).

The study area consists of three samples of conservation areas in South Africa. For this study, I have selected and processed and combined data for 24 provincial parks in KwaZulu-Natal, 8 national parks across the country, and 73 private game reserves in the Western and Eastern Cape Provinces. The private game reserves in this study are informal conservation areas, lacking legal recognition. Figure 1 shows the extent of the analysis and the sample of parks. Colours indicate different types of conservation areas: private game reserves, national parks (managed by SANParks), and provincial parks (managed by Ezemvelo).

The third research question relates to the presence of the Big Five species. For this question, I have only considered provincial protected areas, managed by Ezemvelo, for which I had access to the most extensive financial data. Three of the 24 provincial parks are home to all these species: Hluhluwe-Imfolozi Park, Tembe Elephant Park, and Mkhuze Game Reserve, which is part of the large iSimangaliso Wetland Park.

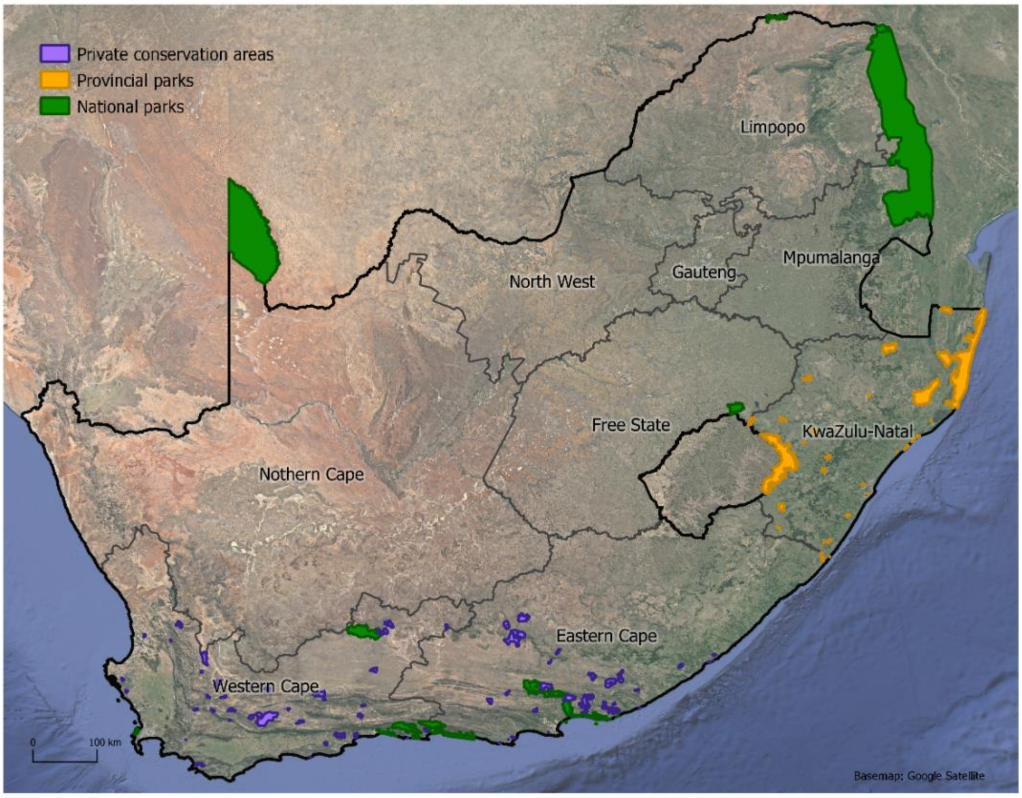


Figure 1. Study area: sample of protected and conserved areas used in the analysis

The data is from different provinces, with substantial differences in the physical environment. South African climate is characterized by two ocean currents: the cold Benguela current on the Western shore and the warm Mozambique-Agulhas current flowing along the East coast. Most of the private game reserves and national parks are located in the semi-arid plateau which is divided from the more humid and lower coastal region by a mountainous “Great Escarpment”. Only a few of these reserves fall into the Mediterranean type coastal area. The Great Escarpment mountain range reaches the western border of KwaZulu-Natal leaving the province between the mountains and the Indian Ocean. KwaZulu-Natal has wide topographical and vegetational variation, from mountainous western parts into grassland and savannah type biome and further into a dry forest along the coastline.

IV. Data and Methods

The thesis is based on quantitative methods which are applied to existing data. My research design is partly relational and partly exploratory: I examine how the net income, revenues, and running costs vary between protected areas of different types and sizes and explore what insights economic simulations may provide about the economic resilience of protected areas. The time horizon of the analysis is one financial year, from March 2019 to February 2020.

For the first and second research questions, 1 assessed and compared the costs and revenues of provincial (Ezemvelo), state (SANParks) and private protected areas in South Africa. I applied basic statistical and spatial analysis to the existing financial and other data (see section 4.3). For the third research question, I created a new simulated dataset based on only Ezemvelo's financial data. I used random Latin hypercube sampling methods to create a larger simulated dataset with a larger variation. The underlying aim of the analysis of simulated data was to better understand how the possible future variation in costs and revenues affects the finances of protected and conserved areas and whether it can indicate something about the economic resilience of these areas. For the fourth research question, the previous results are interpreted through the resilience theory lens.

The financial data was pre-processed, categorised, and partly visualised in Excel, version 16.0.13127. Spatial analyses and maps were made in Q-GIS (version 3.12; QGIS Development Team, 2020). Statistical analyses and the rest of the visualisations were carried out in Anaconda with Python programming language (version 3.7.; Python Software Foundation, 2018) and in R (version 4.0.4; R Core Team, 2020). Method steps are described in more detail in the following subchapters after the data and materials section.

4.1 Data availability

My analysis is based on statistical and spatial data from conservation areas in South Africa. All datasets and sources are listed in Table 2. For financial analysis and modelling I have used three data sources: 1) financial data provided by Ezemvelo

(Ezemvelo KZN wildlife, 2020), 2) socio-economic data on private game reserves in the Eastern and Western Cape (Clements et al., 2016), and 3) management plans and financial reports by SANParks (South African National Parks, 2021).

Table 2. Research materials

Dataset	Geographical area	Time scale (financial year)	Usage	Availability and references
Financial report, visitor data	Provincial parks in Kwazulu-Natal	2019/20	Economic modelling	No open access (Ezemvelo KZN wildlife 2020)
Socio-economic data on private game reserves, spatial data	Private game reserves in Eastern and Western Cape	2013/14	Economic modelling and spatial analysis	No open access (Clements, 2016, pp. 25–32)
Management plans of Kruger, Table Mountain, Garden Route, Addo, Kgalagadi, Golden Gate, Karoo and Mapungubwe	National Parks managed by SANParks	Varied between 2015 and 2020	Economic modelling	Openly available (South African National Parks, 2021) https://www.sanparks.org
SANParks Annual Performance Plan: 2019 - 2020	National parks	2019/20	Economic modelling	Openly available (South African National Parks, 2020a) https://www.sanparks.org
Consumer price indices	South Africa	2014-2019	Adjustment of prices for inflation	Openly available (OECD, 2021) https://stats.oecd.org
Protected areas register and other spatial data	South Africa	2020	Spatial analysis	Openly available (The Department of Environmental Affairs of the Republic of South Africa, 2020) https://egis.environment.gov.za

4.1.1 Provincial park data (KZN)

The financial data provided by Ezemvelo is detailed financial data that covers all operations and services run by Ezemvelo, except game sales (i.e. the selling of live animals to restock other conservation areas). Although the dataset covers six financial years from 2014 onwards, only data concerning the most recent financial year (from March 2019 to February 2020) was used in the analysis.

Ezemvelo's financial data covers both organization-wide costs and protected area level costs, regarding provincially managed protected areas in Kwazulu-Natal. The whole dataset, including systemwide costs, was summarised and used in the organisation-wide assessment and comparison with SANParks (chapter 5.2). For other parts of the analysis, the data were summarized at the protected area level.

In total, 24 protected areas were identified, and costs and revenues were allocated to these reserves. The protected areas which were included in the analysis and the allocation process of costs and revenues into park-level data is depicted in the appendices (appendix 1.) All revenues and costs which were possible to link with a certain protected area were included.

There may be occasional inconsistencies within the financial data, where costs or revenues are categorised differently by different people within Ezemvelo. This could be problematic if analyses of the data were based on very detailed classifications. Broader classes, as used in this thesis, should mitigate these discrepancies. Ezemvelo also provided visitor statistics for some of their parks, which were used to better understand the role of tourism in the economics of protected areas (Ezemvelo KZN wildlife, 2020).

4.1.2 Private game reserve data

This dataset includes socio-economic data for the financial year 2013-2014 regarding private land conservation areas in the Eastern and Western Cape Provinces (see Figure 1). The data is based on a survey with landowners (Clements, 2016, pp. 25–32). From this dataset of 73 game reserves, 21 were excluded due to inadequate or missing financial information. As the data is relatively old, the financial figures have been adjusted based on the annual CPI value to make the data more comparable with provincial and state protected areas data (see chapter 4.2.2).

4.1.3 National parks (SANParks) data

The financial data concerning national parks was retrieved from SANParks' website. I used the financial report section of SANParks Annual Performance Plan (South African National Parks, 2020a) for the analyses of the whole organisation. The report states the total costs, revenues, and net income at an organisational level for the financial year 2019 to 2020.

Management plans of individual national parks were used to find estimated and budgeted costs and revenues at the park level (South African National Parks, 2021). The management plans have been published in different years. If there were no budgeted values for the financial year 2019-2020, I adjusted the numbers for inflation as was done for the private game reserves (4.2.2).

Using financial figures from management plans has obvious limitations, one of which is that running cost budgets, not actual expenses, are provided. In each management plan, there were two different estimations for running costs: the first one was based on the "zero budgeting" approach, meaning that the costs were assessed based on the available funding. The other one consisted of these costs as well as possible additional costs which were seen necessary to fulfil the aims of the management plan, even though they may exceed the pre-defined budget. I used these latter estimations of running costs which result in more negative values than would have been the case with zero-budgeting based running costs. Another limitation of this data is that only a sample of 8 parks was used, which is a smaller sample size than for other parks. However, this was the best economic data available on the protected area level of national parks.

4.2 Data pre-processing

Pre-processing work was carried out to categorise datasets in a comparable way. This process included: classifying and allocating costs and revenues at the park level, adjusting values for inflation, calculating the net income and converting the tabular data into spatial data.

4.2.1 Categorisation of costs and revenues

The categorisation of costs and revenues for all the analyses are summarised in Table 3, with a definition of what is included in each category. In the reserve-level private economic analysis, I focus on total recurring (annual) running costs and total (annual) revenues of protected and conserved areas. Total running costs refer to all costs that relate to the operations within the area but do not include capital expenditure, such as investments and repairments of assets. Total revenues refer to all revenues that are generated within the protected area. The total revenues do not include external (public) funding. Systemwide costs (such as organization head offices, human resource-services, etc.) were not included in reserve-level analyses.

For organisation-level comparisons of funding sources, I categorised the different revenues into tourism revenues, revenues from natural resources and hunting, and other revenues. The running costs were divided into employee-related costs and other operative costs. In this organisation-level comparison, I also included public funding and capital expenses to get an overview of the structure of the whole budget of Ezemvelo and SANParks.

For the economic simulation, I used a third kind of classification method (see Table 3). The simulation also considered only annual running costs and revenues. For the simulation, running costs and revenues were categorised into three classes: tourism revenues, natural resources and hunting revenues, and other revenues; and employee-related costs, administration and marketing costs and other operating costs. This classification was only applied to Ezemvelo's data, as the simulation was only carried out for Ezemvelo.

Table 3. Budget categories

Budget categories used in different analysis			**Details**
Reserve-level economic analysis	*Organisation-level comparisons*	*Simulation modelling*	
Running costs	Employee related costs	Employee related costs	Salaries (employees of the park and lodges etc.), staff trainings and travel costs, other personnel costs
	Other operating costs	Site-level administration and marketing costs	Office materials, software licenses, advertising fees and other marketing expenses
		Other operating costs	Maintenance costs of the park and infrastructure, game feed expenses, herbicides and other supplies, vehicle running cost
	Capital expenditure (asset related costs)		Investments to infrastructure, repair and maintenance of assets, depreciation and amortization
Revenues	Tourism revenue	Tourism revenue	Entrance fees, accommodation, activities, retail, concessions of other tourism operators within the park
	Natural resources and hunting revenues	Natural resources and hunting revenues	Sales of game products and plants, venison, wood and Ncema Grass, trophy and biltong hunting revenues
	Other revenue	Other revenue	Permits, licenses, donations
	Public funding		Funding from the national or provincial government (fixed annual funding + project funding)

4.2.2 Adjustment of prices for inflation

I used the financial year 2019-2020 as a base for all the analysis. However, there is variation in the timespan of financial figures when considering SANParks and private game reserves. To compensate for inflation-related differences between years, I adjusted the nominal values of each revenue and costs category for inflation. For this, I used the general Consumer Price Index of the South African Rand (OECD, 2021). I adjusted the nominal (original) financial values to correspond to the financial year 2019/2020. This was done by applying the formula below:

$$Real\ value_{year\ n+1} = Nominal\ value_{year\ n} \times (1 + annual\ CPI\ year\ n\ /100) \qquad (1)$$

Where real value represents the estimated value for the next financial year and the annual CPI changes according to the year in question.

This formula was then repeated as many times as needed to estimate value in the financial year 2019/2020. This adjustment was made only for private game reserves and protected areas managed by SANParks, as Ezemvelo's data is from the correct financial year.

4.2.3 Calculating net income

Net income or net earnings is an indicator of a company´s profitability. Net income can be called net profit if the outcome is positive, or net loss if expenses exceed the revenues. It is calculated as total revenues minus total running costs:

$$Net\ income = Total\ revenues - Total\ running\ costs \qquad (2)$$

Net income does not consider the costs of assets, such as investments in infrastructure. This is because asset-based costs are usually long-term investments, and their positive effect on revenue may become visible later. The amount of annual asset-based costs may also vary a lot from year to year. For example, renovating all lodges of a park requires large investments over one or a few years but will possibly increase the revenues from tourism substantially for the following years.

4.3 Statistical analysis

I used the combination of spatial and visual analysis methods (maps and boxplots) and non-parametric tests (Kruskal-Wallis). Non-parametric tests were used because the sample sizes of protected and conserved areas vary and the values (net income, running costs, revenues) were not normally distributed. All statistical tests were run in R (version 4.0.4; R Core Team, 2020).

For result section 5.1.1 I compared the medians of reserve-level net income, total running costs and total revenues between different types of protected and conserved areas (SANParks, Ezemvelo and private game reserves). Differences between the types of protected and conserved areas were assessed using Kruskal-Wallis test. Tests were run for both absolute (Rands) and size-relative values (Rands per hectare).

For the result section 5.1.2, comparisons were made based on the size of a protected or conserved area. Based on their size, I categorized all protected and conserved areas into three groups: small reserves (below 2000 hectares), medium-sized reserves (between 2000 and 10 000 hectares) and large reserves (over 10 000 hectares). The categorization was made to compare the finances between reserves of different sizes and, especially, to see whether finances differ between different types of protected and conserved areas even when taking into account the size of the area.

Kruskal-Wallis tests were first applied to the whole dataset containing all different types of protected and conserved areas. I analysed the effect of the size category on both absolute and per hectare net income, running costs and revenues. Separate tests were run to a dataset containing only Ezemvelo's reserves and to others containing only private game reserves. All SANParks' reserves in this sample fall into the large category and thus comparisons could not be made for SANParks.

For the result section 5.3, I compared the revenue sources and expenditure structure of Ezemvelo and SANParks at the organisational level. The financial data from Ezemvelo was aggregated at organisational level, so that all budget parts were involved, including assets and public funding. The structures of organisations' total budgets were compared by looking at the relative proportions of each budget part.

4.4 Analysing the results

My thesis belongs to quantitative human geography with an applied perspective. Data-driven, quantitative human geographical research often lacks a clear theoretical framework, which is crucial to other types of (especially qualitative) human geography. To respond to the critiques that are posed to traditional positivist quantitative human geography (see, for example, DeLyser and Sue, 2014; O'Sullivan et al. 2018), I aim to adopt some practices from the critical human geography approach in the analysis. This critical human geography perspective includes the critical interpretation of the results, understanding the limitations and possible bias in the data, finding underlying assumptions that interfere with the results, and acknowledging the place-specific and cultural settings of the study area. In addition to the critical approach, I use resilience theory to better understand how the economic resilience of protected and conserved areas can be assessed (chapter 6.4).

4.5 Simulation modelling

I carried out a Latin-hypercube based Monte Carlo simulation for the financial data of Ezemvelo's protected areas, to test how random changes in costs and revenues affect the net income. Monte Carlo simulation is a heuristic tool to find the most likely result by repeating the same calculation many times to all samples. Monte Carlo simulation is often used in sensitivity or uncertainty analysis by randomly sampling variables of the model (Khan, Lye and Husain, 2008). I used Latin Hypercube sampling as the basis for Monte Carlo simulation, instead of the more common random sampling. Latin Hypercube sampling is a multidimensional sampling method, that generates nearly random samples, but with less computing capacity than the traditional random sampling method.

The Latin Hypercube sampling-based Monte Carlo simulation was carried out using Python (Python Software Foundation, 2018) and the pyDOE package (Dietrich et al. 2017). The first step was to create a random sample matrix of 100 rows and 6 columns based on the Latin hypercube sampling method. An extended dataset was then created where values of the three revenue and three cost categories (see Table 3.), were varied randomly within the range of + 10% of the maximum and -10% of the minimum values. This was carried out both for absolute and per hectare values. A hundred extra rows were added in the simulation, based on the range of possible values and the corresponding Latin Hypercube sampled cell value. All revenue and cost categories were varied simultaneously. Net income was then calculated for each simulated row, by subtracting running costs from revenues.

The result of this simulation is presented in chapter 5.3.1 as boxplots. The simulated dataset was further grouped based on whether the protected area was home to all Big Five species or not (chapter 5.3.2). The two-sample Kruskal-Wallis test was used to compare the medians of protected areas with and without all Big Five species.

V. Results

Results consist of three parts. The first part is based on an analysis of the existing economic data of different protected and conserved areas, addressing research questions 1a and 2. The aim is to compare the economic structure between different types of protected and conserved areas, at protected area level. In the second part, the economic structure of public protected areas (Ezemvelo and SANParks) are compared at organisational level (research question 1b). The third part is based on simulation modelled data and only considers Ezemvelo's protected areas. In this part first, the potential changes in net income are examined based on the simulation and then a comparison is made between parks that are home to the Big Five species and those that are not (research question 3). Research question 4, which is about the potential economic resilience of different protected and conserved areas is further discussed in chapter 6.4, as part of the discussion chapter.

5.1 Reserve-level cost-revenue structure

5.1.1 Comparison between SANParks, Ezemvelo and private game reserves

Both the distribution and the median of net income varies between different types of protected and conserved areas, as can be seen in Figure 2a (absolute values) and Figure 3a (relative, per hectare values). Based on this dataset, the median of park-level net income is the lowest for SANParks, followed by Ezemvelo. Both SANParks and Ezemvelo have negative median net income (net loss) whereas private game reserves have positive net income.

The distribution of net income across Ezemvelo's protected areas is negatively skewed. Most of Ezemvelo's protected areas are making a modest net loss but some protected areas have a very large net loss which extends the left tail of the distribution. The outliers, which have an exceptionally high net loss, represent the largest parks managed by Ezemvelo: iSimangaliso Wetland Park, uKhahlamba Drakensberg Park and Hluhluwe-Imfolozi Park. For private game reserves, it is the opposite: most of the parks break even or generate little revenue, but the distribution grows for parks earning more than that. The distribution of net income is highest for SANParks (Figure 2a). However, figure 3a reveals that SANParks' net income per hectare is closer to zero and far less distributed than in Ezemvelo's parks.

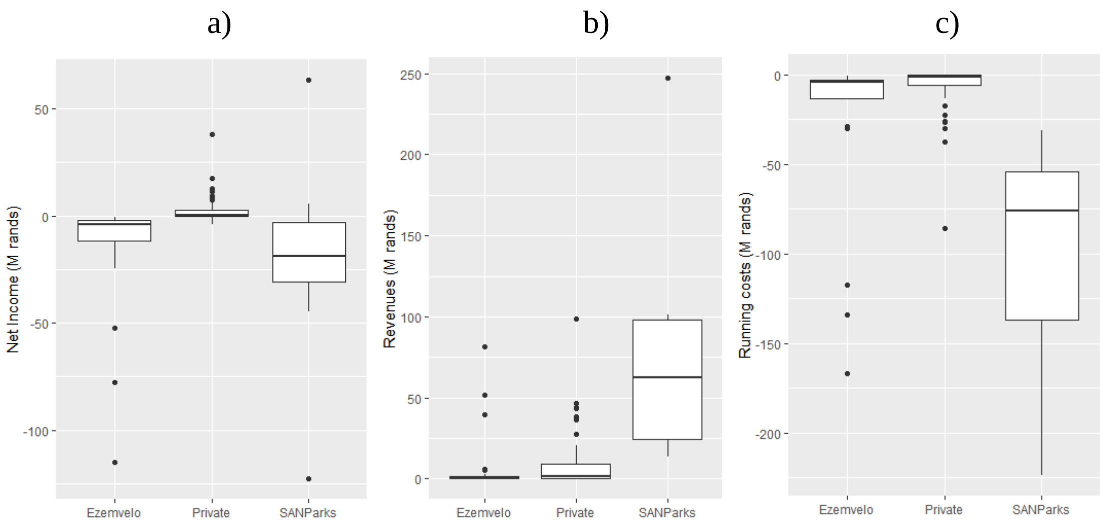


Figure 2. a) Net income, b) revenues and c) running costs in millions of South African Rands by type of protected area for the financial year 2019-2020. Kruger National Park is excluded from the revenues (Figure 2b) and running costs (Figure 2c) as an outlier as its estimated running costs and revenues both exceeded R1150 million.

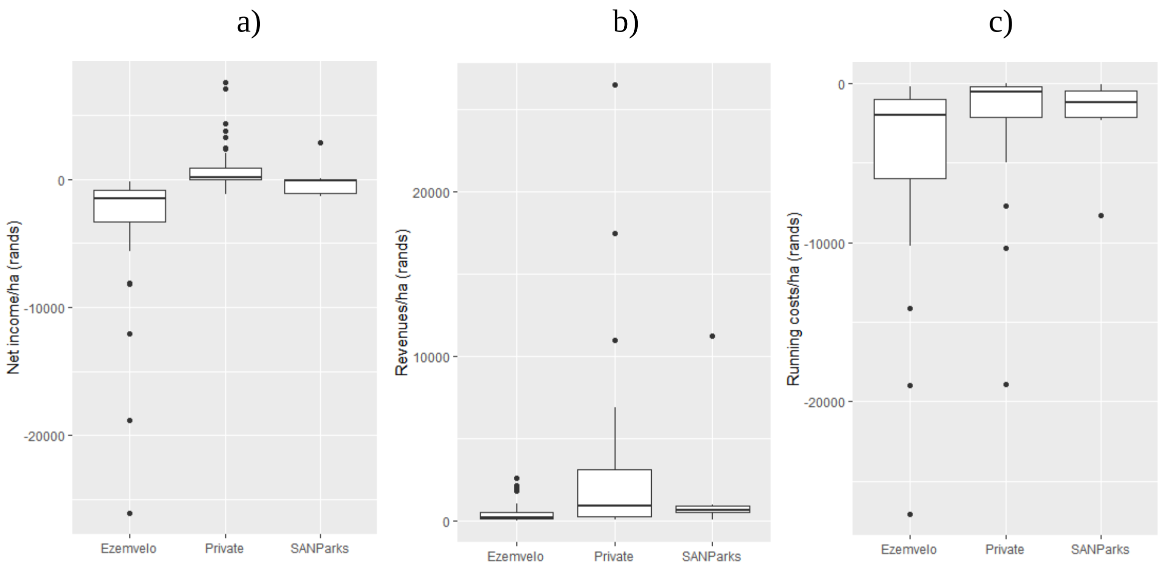


Figure 3. a) Net income, b) revenues and c) running costs per hectare in South African Rands by type of protected area for the financial year 2019-2020.

The differences in park-level net income between different types of protected and conserved areas are statistically significant according to Kruskal-Wallis test results. Kruskal-Wallis test allowed me to reject the null hypothesis that there was no difference in net income among different types of protected and conserved areas, both based on absolute (net income in Rands, $H(2)=45.87$, $p\text{-value}<0.001$) and size relative (net income/hectare, $H(2)=49.42$, $p\text{-value}<0.001$) values. Furthermore, two-sample Kruskal-Wallis test reveal that at a .05 significance level there is a significant difference in net income between private game reserves and Ezemvelo ($H(1)=47.57$, $p\text{-value}<0.001$), and between SANParks and private game reserves ($H(1)=6.0385$, $p\text{-value}=0.014$), but not between SANParks and Ezemvelo ($H(1)=1.10$, $p\text{-value}=0.294$).

Also, the absolute revenues and running costs vary significantly among different types of protected and conserved areas (revenues: $H(2)=21.89$, $p\text{-value}<0.001$, running costs: $H(2)=27.63$ $p\text{-value}<0.001$). This time, there are significant differences between all types of parks, at a .05 significance level. However, with per hectare values, the difference of revenues and running costs remain significant only between private game reserves and Ezemvelo (revenues/hectare: $H(1)=11.15$, $p\text{-value}<0.001$, running costs/hectare: $H(1)=8.50$, $p\text{-value}=0.004$).

Both revenues and running costs are generally the biggest for national parks, indicating that the magnitude of cash flows are greater for national parks (see Figures 2b and 2c). Most of the parks managed by Ezemvelo have little revenues (Figure 2b), but also moderate running costs (Figure 2c). The running costs per hectare are much greater for Ezemvelo than other types of parks (see Figure 3c). The biggest per hectare running costs are incurred by the smallest parks: Mpenjanti Nature reserve, Harold Johnson and Kenneth Stainbank Nature Reserves.

Private game reserves have smaller absolute and size-relative running costs than Ezemvelo or SANParks. Private game reserves also generate the highest revenues per hectare, although there is big variation between reserves. The size-relative highest-earning private game reserve is a very small conservation area, below 10 hectares.

5.1.2 Size-dependent variation

The effect of size category is the most evident in Ezemvelo's case (Figure 4). There are clear size-dependent differences across Ezemvelo's parks, especially concerning the net income and running costs per hectare (Figure 4b and c). Smaller parks (below 2000 hectares) have both greater running costs and greater net loss per hectare than large parks (over 10 000 hectares) and medium-sized parks fall in the middle. Indeed, there was a statistically significant difference among Ezemvelo's parks when considering park size. This holds for both absolute net income values ($H(2)=13.87$, p-value <0.001) and relative, net income per hectare values ($H(2)=14.71$, p-value<0.001). Running costs per hectare changed significantly between different size categories ($H(2)=14.97$, p-value< 0.001), but there is no significant difference in revenues per hectare ($H(2)=3.08$, p-value$=0.215$).

According to Kruskal-Wallis tests, size category does not have statistically significant influence on net income or net income per hectare when all different types of protected and conserved areas are included (net income: $H(2)=1.95$, p-value$=0.305$; net income per hectare: $H(2)=1.20$, p-value$=0.550$). Size category has no statistically significant influence on revenues per hectare either ($H(2)=2.12$, p-value$=0.349$). However, running costs per hectare varied significantly ($H(2)=6.35$,

a) b) c)

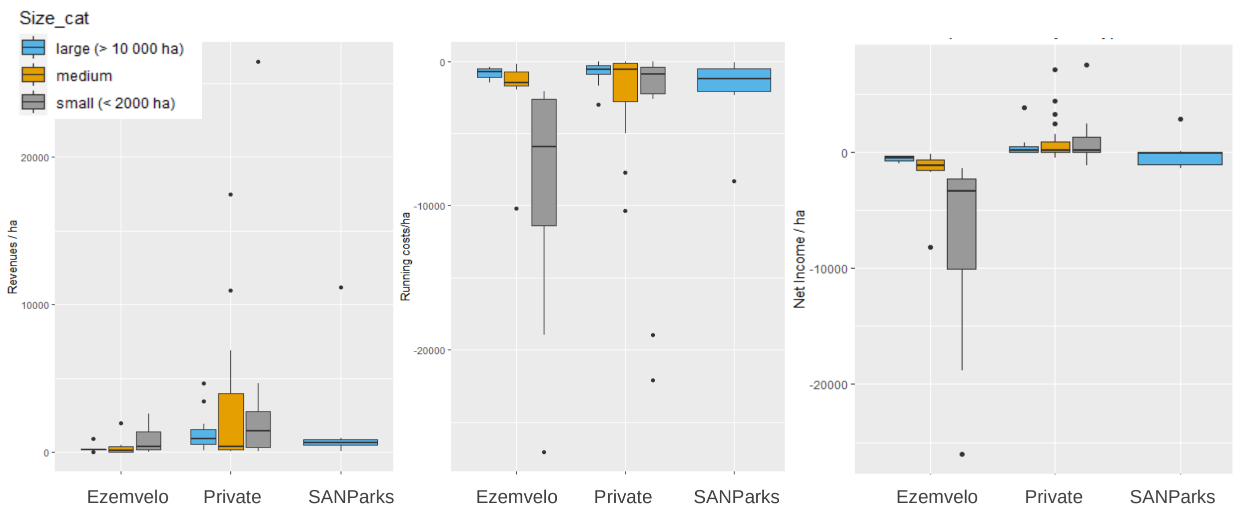


Figure 4. a) Revenues, b) running costs and c) net income per hectare, by type and size of protected area. All national parks in the sample fall into the "large" category. A small private game reserve was dropped as an outlier from the figures 4a and 4c as its revenues per hectare exceeded 900 000 Rands.

p-value=0.042), as did the absolute revenues (*H(2)=36.10, p-value<0.001*) and absolute running costs (*H(2)=36.25, p-value<0.001*) when all protected and conserved areas are included. Size has clear but non-linear effect on the running costs per hectare of public protected areas: costs per hectare increase exponentially as the size decreases, for protected areas below 1000 hectares (Figure 5).

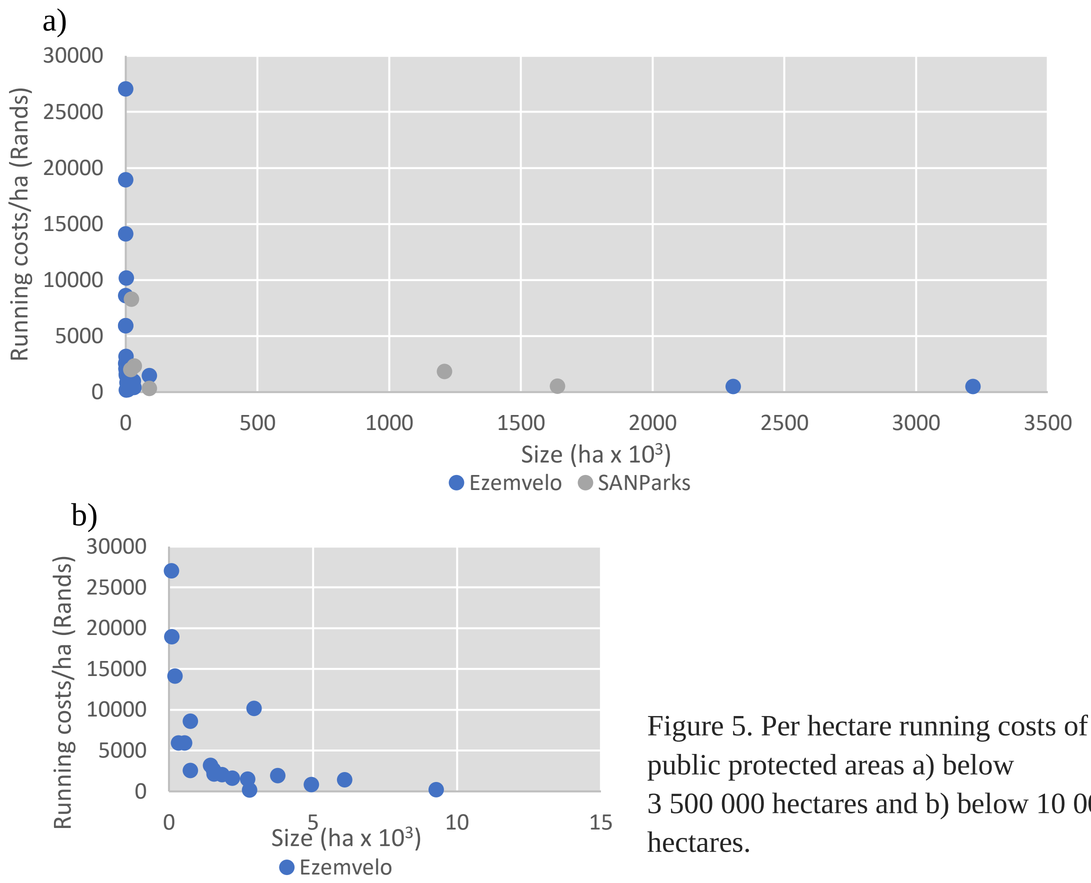
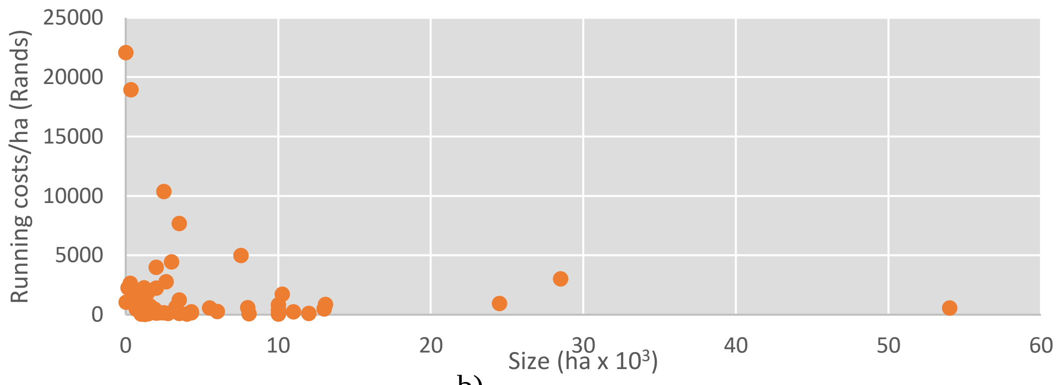


Figure 5. Per hectare running costs of public protected areas a) below 3 500 000 hectares and b) below 10 000 hectares.

The size category does not make a difference in the case of private nature reserves. For private reserves the median revenues per hectare are the least for medium-sized parks, then large parks and most for small parks (Figure 4a). When it comes to the private game reserves, there are no statistically significant differences in per hectare net income (*H =0.19, p-value = 0.91*), running costs (*H = 0.65, p-value = 0.72*) or revenues (*H=0.77, p-value=0.68*) between size groups (Figure 4 and 6).

a)



b)

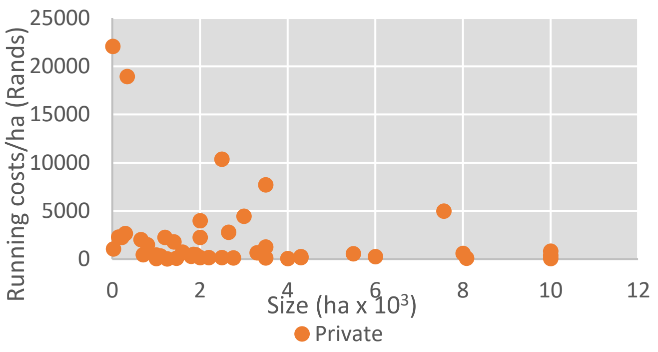


Figure 6. Per hectare running costs of a) all private game reserves and b) private game reserves below 10 000 hectares.

5.2 Organisation-level comparison, Ezemvelo and SANParks

In this section, I compare the whole organization-wide budgets of SANParks and Ezemvelo. Figure 7 shows that public funding comprises the majority of funding to

a) b)

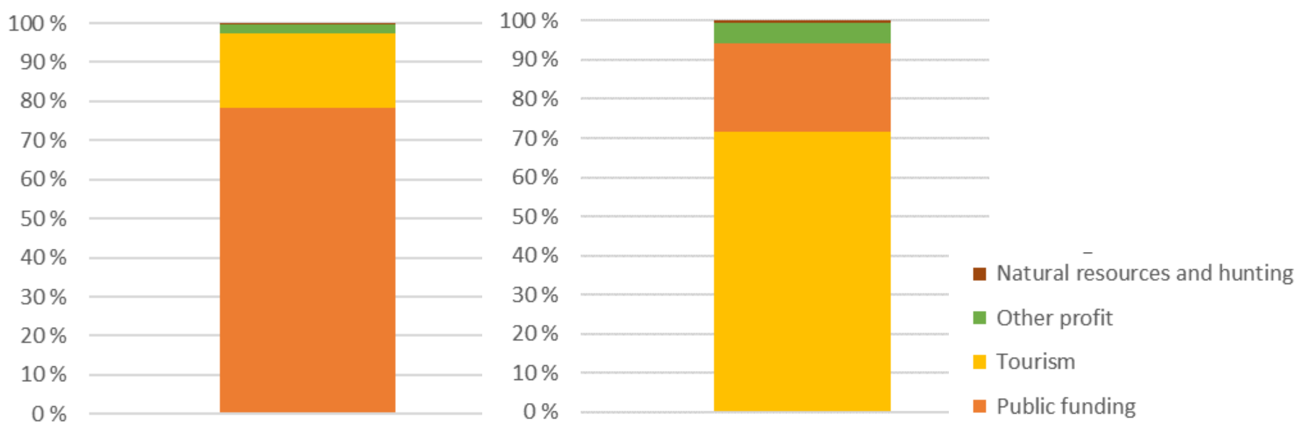


Figure 7. Comparison of sources of funding between a) Ezemvelo and b) SANParks for the financial year 2019-20. This comparison is organization-wide, including all park- and organization-level funding.

the organization Ezemvelo (78%). Tourism revenue is the second most important source of funding, consisting of 20% of the total funding. For SANParks, by contrast, tourism is a much more important source of revenue than for Ezemvelo, generating over 70% of all funding. The share of government funding is only one quarter (23%).

Other revenues, such as donations, permits and fines, interest income and other operating income comprises only around 2% of Ezemvelo's total revenues. For SANParks, the share of other revenue is slightly more. The role of natural resources and hunting is very marginal for both (less than 1%).

Figure 8 shows the organization-level running and capital expenditure of Ezemvelo and SANParks. The share of employee-related expenses is over 70% of Ezemvelo's total expenditure but only 44% of SANParks' expenditure. For SANParks, other operating costs (including lease payments) constitute almost the same amount of expenses as employee-related costs. SANParks use a bigger share of their total expenditure for investments and other asset-related costs. These make up over 10% of the total expenditure, as for Ezemvelo it comprises only 4%.

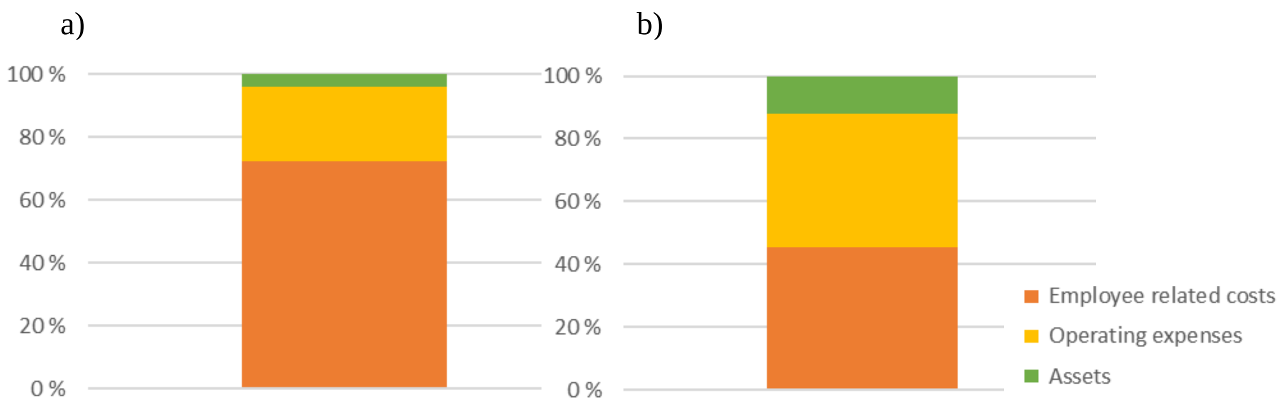


Figure 8. Comparison of running and capital expenses between a) Ezemvelo and b) SANParks, for the financial year 2019-20. This comparison is organization-wide, including all expenses of the organization.

5.3 Simulated data results (Ezemvelo)

5.3.1 Potential future variation in net income

The simulated data shows how reserve-level net income varies in different scenarios, based on random variation in costs and revenues. Only a few of Ezemvelo's protected areas have positive values for net income in any of the simulated scenarios (Figure 9). These areas are Hluhluwe-iMfolozi Park and Umlalazi nature reserve. Hluhluwe-iMolozi Park is a large protected area and one of the few parks in South Africa which is home to all the Big Five species (rhino, lion, leopard, buffalo and elephant), whereas Umlalazi is a small coastal nature reserve, close to Mtunzini and not far away from Richards Bay (Figure 10).

Parks that have the greatest distribution in potential net income are iSimangaliso, Hluhluwe-Imfolozi Park and Ukhahlamba Drakensberg Park. According to the simulation, their net income is more sensitive to changes in revenues and costs, although that is also because they have the biggest budgets.

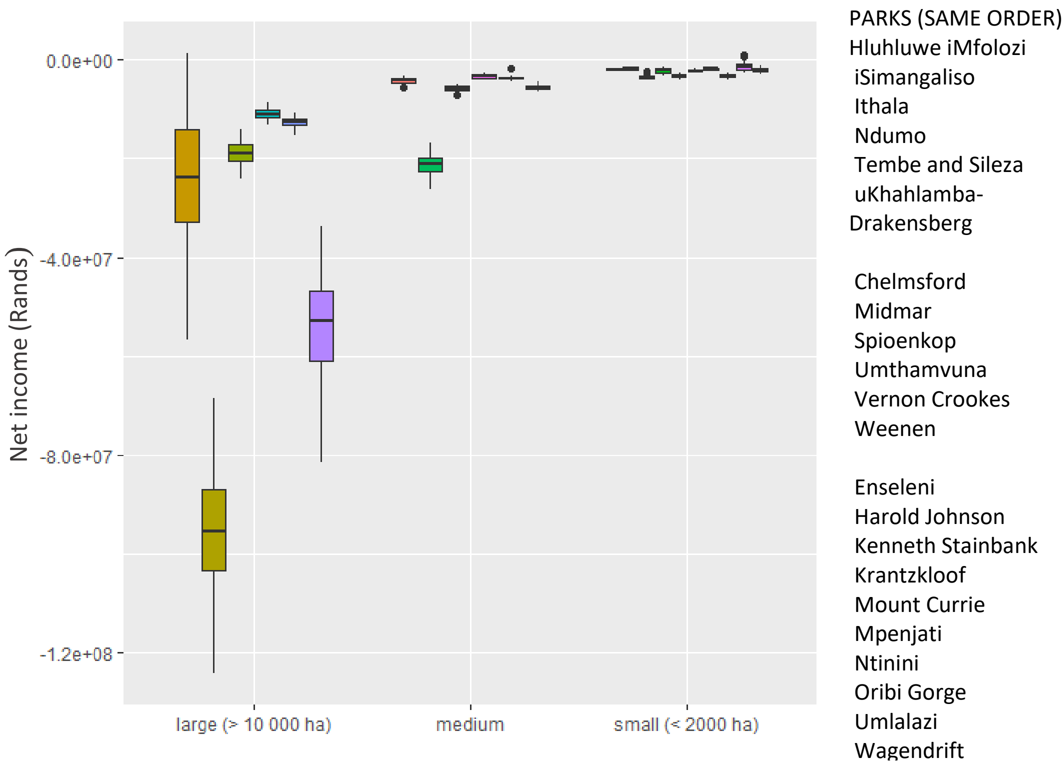


Figure 9. Simulated net income across Ezemvelo's protected areas. The simulation was made using a variation range of -10 to 10%, to each cost and revenue category.

The map (Figure 10) shows the magnitude of net loss by protected area based on Ezemvelo’s actual data. In general, the amount of net income follows the size of the park as was concluded in section 5.1.2: large parks have the largest net loss, small parks the least and medium-sized parks fall into the middle. Those parks which generate the most income tend to also have the biggest net loss. Running costs generally exceed the revenues multiple times. Hluhluwe-Imfolozi Park is an exception to this: its revenues cover two-thirds of the total running costs.

On the other hand, net loss per hectare is generally bigger in small protected areas than in larger ones. There are two exceptions to this. Ntsikeni is a medium-sized park but has a lower net loss than most of the smallest parks (Figure 10, Table 4). This

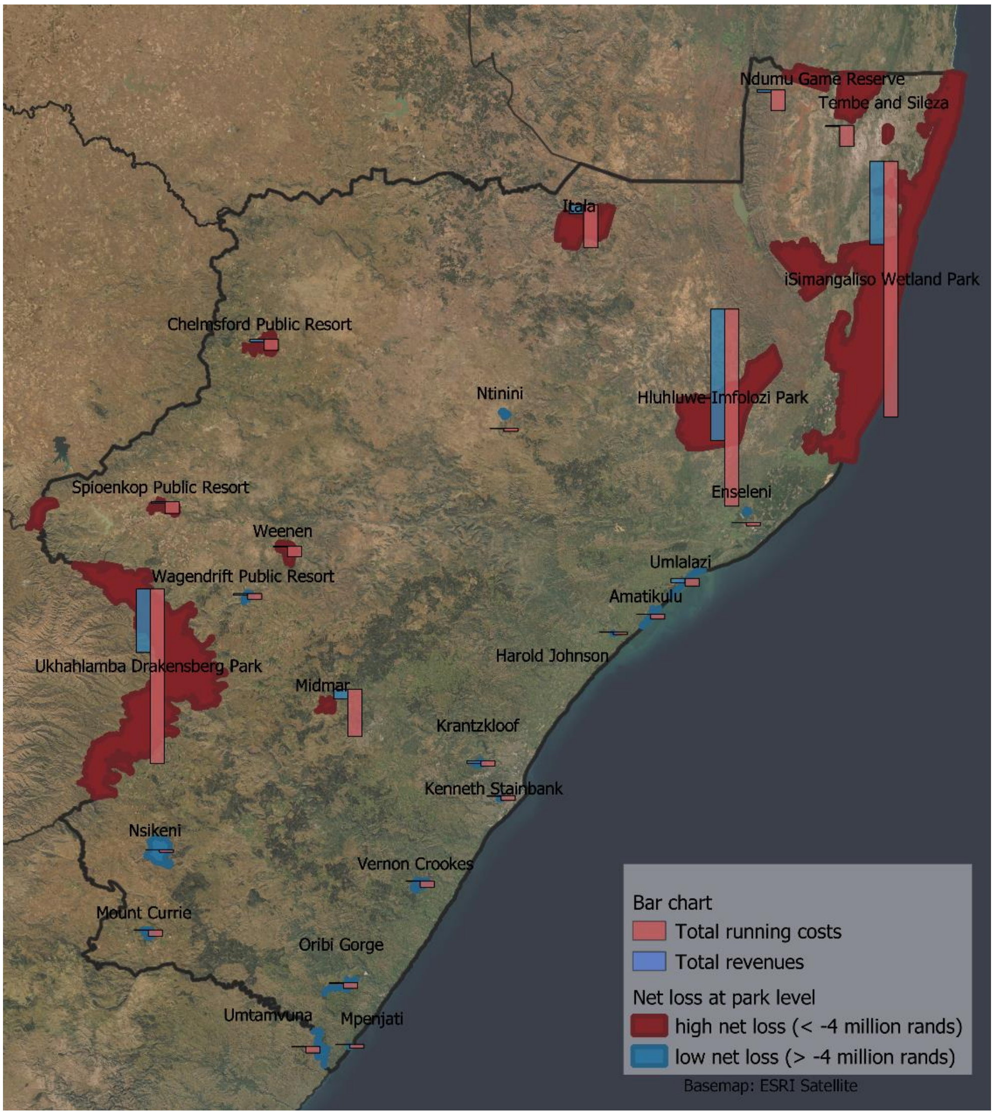


Figure 10. Protected areas of high and low net loss in Kwazulu Natal. Bars show the amount of revenue and running costs generated by each park in financial year 2019-2020.

means that the net loss per hectare is lower for Ntsikeni than for medium-sized parks in general. Ntsikeni has low running costs and, according to the data, no revenues at all. Midmar instead is a medium-sized park that has greater net loss than many larger parks, resulting in larger net loss per hectare than other medium-sized parks. It has relatively high visitor numbers and revenues, but also high running costs (see Table 4). Midmar stands out also in both simulation boxplots as having both high absolute (Figure 9) and size-relative (Figure 11) net loss and variation of net loss.

Table 4. Economic figures and overnight visitor numbers of Ezemvelo's protected areas. Bold figures represent the five highest value in each column (in the case of net income, the largest net losses)

Park	Net income (million Rands)	Total revenues	Total running costs	Visitor numbers	Size
Harold Johnson	-1.576	0.019	1.594	No data	small (< 2000 ha)
Ntsikeni	-1.628	0	1.628	No data	medium
Ntinini	-1.662	0.125	1.787	No data	small (< 2000 ha)
Krantzkloof	-1.75	1.428	3.178	26600	small (< 2000 ha)
Enseleni	-1.835	0.119	1.954	7500	small (< 2000 ha)
Umlalazi	-2.033	2.596	4.629	**28000**	small (< 2000 ha)
Mpenjati	-2.242	0.092	2.334	7800	small (< 2000 ha)
Kenneth Stainbank	-2.559	0.454	3.013	10300	small (< 2000 ha)
Wagendrift	-2.626	1.005	3.631	15200	small (< 2000 ha)
Amatikulu	-2.994	0	2.994	No data	small (< 2000 ha)
Oribi Gorge	-3.161	0.435	3.596	1700	small (< 2000 ha)
Mount Currie	-3.685	0.225	3.91	3600	small (< 2000 ha)
Vernon Crookes	-3.827	0.112	3.939	1000	medium
Umthamvuna	-3.916	0.039	3.955	1000	medium
Chelmsford	-5.086	1.883	6.969	17900	medium
Weenen	-5.978	0.366	6.344	1800	medium
Spioenkop	-6.517	0.806	7.322	12900	medium
Ndumo	-11.182	1.527	12.709	300	large (>10 000 ha)
Tembe and Sileza	-12.284	0.598	12.882	No data	large (>10 000 ha)
Ithala	**-21.075**	**5.475**	**26.55**	4100	large (>10 000 ha)
Midmar	**-23.284**	**5.848**	**29.132**	**45800**	medium
Hluhluwe iMfolozi	**-40.835**	**81.744**	**122.579**	**111500**	large (>10 000 ha)
UDP	**-69.182**	**39.573**	**108.755**	**97700**	large (>10 000 ha)
iSimangaliso	**-107.284**	**51.626**	**158.91**	**36900**	large (>10 000 ha)

Most of the differences in the sensitivity of net income between parks can also be explained by their size, based on the simulations. As can be seen from figure 11, variation in net income per hectare is greater for smaller parks than larger ones. From the large parks, Ndumo, Tembe and Sileza, and Ithala have the least variation in net income per hectare. They have the lowest net loss of the large parks both in the existing and simulated data. Mpenjanti again has the highest net loss per hectare in the existing and simulated data and the highest variation in simulated net income.

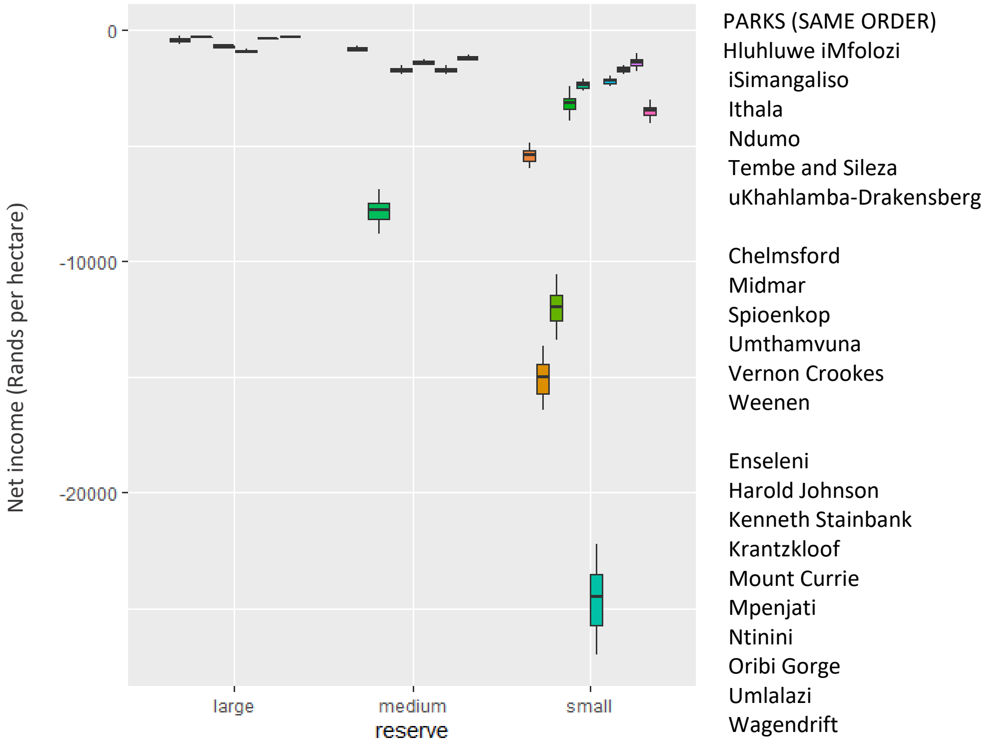


Figure 11. Simulated net income per hectare, across Ezemvelo's protected areas. The simulation was carried out using a variation range of +-10% of maximum and minimum values in each cost and revenue category.

5.3.2 Big Five protected areas

Protected areas which are home to all Big Five species count only three against 24 remaining protected areas without all the five species. Still, protected areas with all Big Five species have higher variation in absolute net income based on the simulated data (see Figure 12a), even though they have a high net loss in the original data. Based on the simulation, in some scenarios, these parks could break even but mainly they are generating bigger net loss than parks without all Big Five species when it comes to absolute, reserve level net income.

Ezemvelo's protected areas home to all Big Five species have significantly lower net loss per hectare in the simulated data than other Ezemvelo's parks, based on Kruskal-Wallis test (*H(1)=2565, p-value<0.001*) and Figure 12b. The size of the parks may affect the results here also, as all the Big Five parks fall into the large category (parks over 10 000 hectares). However, based on Kruskal-Wallis test result there are still significant differences in net income per hectare between the Big Five parks and other, large parks managed by Ezemvelo *(H(1)=89.78, p-value<0.001*).

Hluhluwe-Imfolozi Park generates the most revenues of all parks, and the second is iSimangaliso Wetland Park (Table 4). This result is aligned with the hypothesis of Big Five parks having the greatest revenues. However, Tembe Elephant park provided an unexpected result as it is not following the hypothesis: despite it being a large park and home to Big Five species, it has very little revenue (Table 4). All these parks have high running costs at the park level but per area unit, the costs are much lower than for other parks.

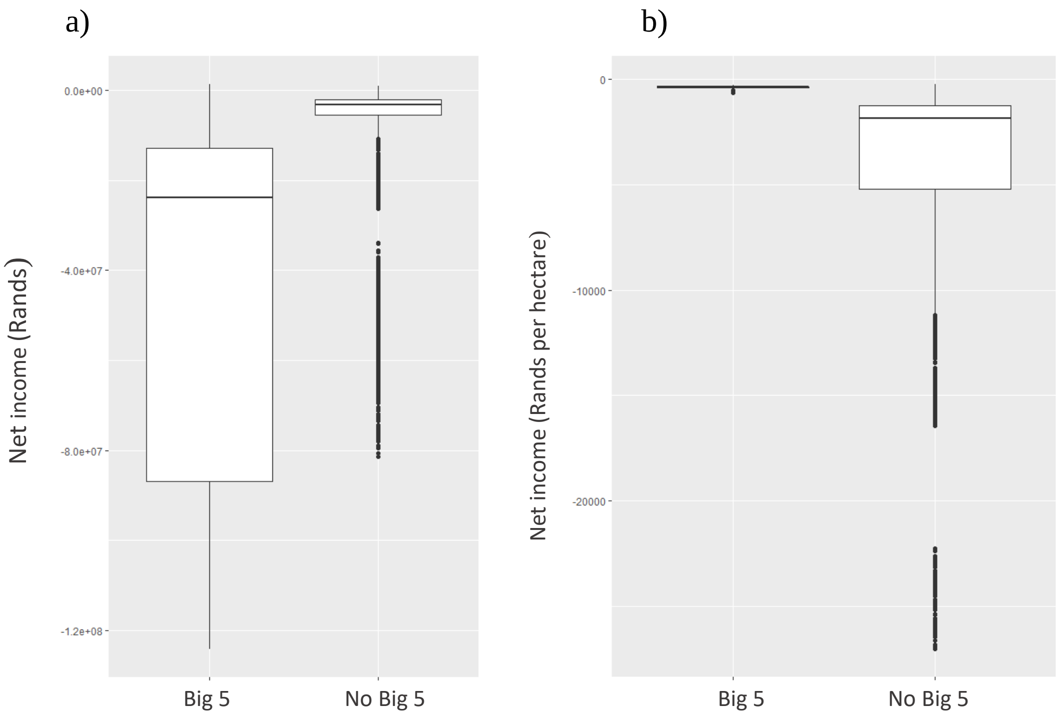


Figure 12. Simulated a) net income and b) net income per hectare in parks which are (Big 5) and which are not (No Big5) home to all Big Five species (rhino, lion, leopard, buffalo and elephant)

VI. Discussion

6.1 Variation in costs and revenues between Ezemvelo, SANParks and private

According to the data used in this thesis, the type of protected area (provincial, national or private) is a more important attribute to explain variation in net income than the size of the conserved or protected area. The biggest differences were seen between private game reserves and public protected areas. Private game reserves were the only areas with a positive median net income. National Parks had the highest net losses on average, followed by Ezemvelo Provincial Parks. Results align with Chidakel et al. 's (2020) research concerning the economic performance and functional resilience of protected areas in the Greater Kruger National Park. According to their results, private game reserves which are part of the integrated network of reserves called the Greater Kruger National Park, were the most profitable when compared to other reserves in the system managed by SANParks and provincial authorities. When it comes to Kruger, SANParks did make a profit and provincial parks were the only ones that could not self-finance their park management (Chidakel et al., 2020). This result indicates that economic analysis should be carried out separately for each type of protected area and that results should not be generalized over different types of protected and conserved areas without caution.

In absolute revenues, there were significant differences between all types of protected and conserved areas. Absolute revenues were highest for national parks, probably in part due to their large size, and the greater public awareness of and thus visitation to these parks. In comparison with Ezemvelo's parks, which generally generated the lowest revenues, SANParks higher revenues may also be explained with possibly more infrastructure to accommodate visitors. However, when it comes to revenues per hectare, SANParks only generate moderate revenues. Private game reserves are typically much smaller than state parks, yet still generate high revenues. One of the reasons behind this could be that private game reserves gain most of their revenues from lodges which attract visitors despite small reserve size.

On the running cost side, private game reserves had the lowest and SANParks the highest absolute running costs, and Ezemvelo falls into the middle. The median running costs per hectare was also smallest for private game reserves, even though some of these reserves have very high revenues per hectare, which could indicate more intensive tourism and wildlife related operations. On the other hand, private game reserves are obligated to less regulation related to conservation operations and targets, which may result to lower costs. When it comes to running costs per hectare, the differences remained statistically significant only between private game reserves and Ezemvelo, whereas SANParks' running costs per hectare fall in between resembling both Ezemvelo and private game reserves. This, and the results stated earlier indicate, that the protected area economics is more similar between private game reserves and SANParks (and between SANParks and Ezemvelo), than between private game reserves and Ezemvelo.

The running costs of parks exceed the income generated within the area for all parks managed by Ezemvelo, which means that the calculated net income for each park is negative. The park-level net income does not consider any external funding, which covers a majority of Ezemvelo's total budget (see chapter 5.2). Both absolute and size-relative running costs were significantly lower in private game reserves, than Ezemvelo's parks, which may partially be explained by possibly more extensive (and expensive) conservation operations carried out by Ezemvelo (e.g., alien eradication, vegetation restoration, species conservation). In addition, the biophysical differences may also play role in explaining the variation in running costs between Ezemvelo and private game reserves. The results of spatial variation in management costs across Africa (Moore et al., 2004) indicate that annual management costs per hectare are generally higher in KwaZulu-Natal Province and the Southernmost shores, than inland in the Western and Eastern Cape Provinces, where most of the private game reserves are located, as a result of differences in climate and vegetation conditions.

Both Ezemvelo and SANParks receive grants from provincial or state governments but this funding is not adequate to cover their costs. The organization-wide comparisons between Ezemvelo and SANParks show that tourism contributes a higher proportion to the budget of SANParks than to the budget of Ezemvelo. Even if conservation literature in the sub-Saharan African context tends to focus on the importance of tourism revenues in conservation, the share of this income source is relatively small in Ezemvelo's budget, at least if compared with SANParks. For Ezemvelo there is potential to grow this share of income source through investments into infrastructure and tourism facilities. On the other hand, the smaller role of tourism revenues means the impact of COVID-19 may have been less critical for provincial parks, compared to other, more tourism-reliable protected areas. All datasets end by the 29th of February in 2020 which means that the effect of the COVID-19 pandemic cannot be seen in the data.

Hunting has very little role in the funding of Ezemvelo's conservation. Within the sample parks, hunting only generates 100,000 rands, while other natural resources generate six times more revenues but having still little impact on the total budget. Hunting is not undertaken in any parks managed by SANParks and thus there is no revenue at all from hunting. By contrast, hunting is a major contributor to revenues on private reserves, with 50% of reserves undertaking this activity (Taylor et al. 2020).

Differences between the types of parks arise partially from different management targets and strategies. As public entities, Ezemvelo and SANParks have substantially different management strategies and aims than private conservation areas. Their core mandate is conservation and not profit-making, unlike for some of the private game reserves (Clements et al., 2016). Conservation is seen as intrinsically valuable and conservation action is not driven by the possibility of revenue generation. Public conservation authorities also have different responsibilities regarding social responsibility and equity. Over 70% of Ezemvelo's budget goes to salaries and other employee-related costs whereas for SANParks salaries total 45% of the budget. Public protected areas indeed have a substantial effect on locals livelihoods both via direct employment and economic "spill-over" effect, mainly related to increased tourism activity (Chidakel et al., 2021). Reasonable entrance fees and accommodation prices enable the parks to be accessible to more South Africans to enjoy the natural wonders of KwaZulu-Natal. In this sense, Ezemvelo has an important socio-political role in the province. Ezemvelo also runs community projects. However, according to Chidakel et al. (2021) private reserves actually have even greater socio-economic contribution to the region in terms of economic spill-over, than public protected areas.

Unlike in the case of private protected and conserved areas, the conservation authorities who manage public protected areas have a total organization-wide budget, which is then used to allocate money to different protected areas. Ezemvelo’s and SANParks’ budgets consist of public funding (state funding or funding from KwaZulu Natal’s provincial government) and self-generated funds. Therefore, only looking at the park level revenues and costs may give a misleading picture of the economics of public protected areas. For example, although the analysis of the sample of national parks used in this thesis would indicate that National Parks are on average less financially viable than Ezemvelo Parks, SANParks had a budget surplus while Ezemvelo had a budget deficit at the organizational level. Different management systems and strategies explain the larger variation in revenues and net income for public protected areas: it is part of SANParks’ strategy to have a few parks which generate high net incomes which are then shared with all the other parks which may have stricter conservation agendas or otherwise attract fewer visitors (South African National Parks, 2021). By contrast, no Ezemvelo parks make a positive net income to help fund other parks, making the organization as a whole more heavily dependent on government funding and donors.

Private conservation areas on the other hand need to be self-sustained or funded by money from the owner, as they receive no government funding. This puts more pressure on private game reserves to find ways to be financially viable, and even force to close if the landowner cannot fund them from their other income. This is the main reason behind the differences in net income between public and private protected and conserved areas. According to Clements et al. (2016), the management objectives of private game reserves vary from profit generation to more intrinsic motives which derive from valuing the landscape and animals and sense of place. The management objectives and business models may affect the cost-revenues structure of a private game reserve through different choices regarding the operations and investments, such as how much money is used in voluntary conservation operations and whether investments are targeted only to improve infrastructure for tourism. Private game reserves generate income from consumptive and non-consumptive activities (hunting and photographing tourism, for example) and mixed land use activities, such as cattle farming, wildlife ranching and taxidermy. This diversity of revenue streams, together with less regulation and the following ability to scale voluntary conservation operations and other non-fixed costs based on existing funds, may result to greater viability of private game reserves as opposed to public protected areas.

6.2 Economies of scale

Running costs per hectare decrease significantly as the size of the park increases. In that sense, the “economies of scale” phenomenon is evident. This finding makes sense as there are certain costs that needs to be covered regardless the size of the protected area, but which do not scale up linearly as the size of the protected area increases. For example, there may be a need for minimum number of staff, but beyond a certain size, less staff is needed per hectare. Administration and marketing costs are another example of costs which are size-relatively higher for smaller protected areas.

Based on the total dataset, the threshold size for economies of scale would be around 1000 hectares: the running costs increase exponentially the smaller the area is for protected areas below 1000 hectares. For larger protected areas the size does not have such a big influence on costs per hectare. This result is aligned with earlier studies by Adams et al. (2012) and Frazee et al. (2003), where a threshold reserve size of 1000 hectares in Northern Territory, Australia (Adams et al., 2012) and 600 hectares in Cape Florence area in South Africa (Frazee et al. 2003) were identified, below which the running costs per hectare start to increase rapidly. Based on this result, in future if protected areas were to be categorised into different size groups to assess their financial viability, 1000 hectares could be used as the upper limit for small parks, instead of the 2000 hectares which was used in the analysis of this thesis.

In addition to the cost advantages based on the economies of scale, the lower per hectare running costs of larger protected areas may also be explained by the locational characteristics of the area. Larger intact areas are more likely located further away from population centres and other intense land uses and thus encounter less anthropogenic pressures. This may again be seen in the running costs if less security and maintenance is needed as there is less people living close to the borders of a protected or conserved area. Also, in general, anthropogenic pressures are higher around the borders of protected areas. As larger protected areas tend to have bigger intact areas far away from the borders of the area, it is expected that the costs are lower for the bigger protected and conserved areas.

What is surprising, is that when private game reserves were considered separately, there was no significant connection between the size of the conserved area and the running costs per hectare. Therefore, it seems that for private reserves the size and the economies of scale effect are not dominant factors to determine the running costs per hectare. This may be due to the variation of biophysical attributes (such as species richness) or differences in management objectives and strategies across private game reserves. Informal private game reserves may have very varied cash inputs into the management of the park, its services and wildlife, depending on their business model. For example, Clements (2016) identified two very different business models for small private game reserves: "budget reserves" were characterised by small size, absence of charismatic game species and small diversity of other game species and cheap self-catered accommodation, with presumably low running costs per hectare. At the other end were small reserves that are rich in charismatic game species, and target for high-end customers providing guided activities, and having presumably higher running costs per hectare. Similarly, two very different business models were identified for large game reserves, too (Clements et al., 2016).

Even though size affected the running costs per hectare when considering the whole dataset of different types of protected areas, the size category was not statistically significant in determining net income per hectare, or even the absolute annual park-level net income. This was evident also when only looking at the private parks: absolute running costs and revenues were significantly different between different sized reserves if considered one at the time, but the values (revenues and costs) are distributed in a way that there are no significant changes in the net income (the sum of revenues and costs) across parks of different size. Thus, the type of protected area is a more important attribute to determine the net income than the size.

When considering Ezemvelo's parks separately, the running costs per hectare are greater for smaller parks than for larger parks, even though three of the six largest parks are home to all the Big Five species, which are connected to greater management costs. Therefore, it seems that the presence of Big Five species do not particularly increase the per hectare running costs of a protected area, at least not as much that it would overcome the cost savings from economies of scale. Although absolute revenues, as costs, increase with size in Ezemvelo's parks, the absolute revenues do not cover the absolute running costs in any of the parks and thus, the largest parks generate the biggest net losses.

6.3 Protected areas with big five species

Based on the simulation results, possible changes in costs and revenues have a bigger impact on protected areas with big five species than others. This may partially be explained with bigger budgets in general: big five parks have high revenues but also high costs and thus the variation in net income may appear larger if costs and/or revenues change. Large predators, such as leopards and lions require large territories and the effect that the big five species have on net income is thus hard to distinguish from the effect that size has. Although there seemed to be significant differences in simulated net income per hectare between big five parks and non-big five parks also among the "large park" category, the sample of large protected areas was too small to enable statistical comparison.

What is interesting is that in Ezemvelo's parks, the presence of the big five species does not generate enough money to compensate for the larger management costs. Hluwhele-Imfolozi Park has the biggest revenues of all Ezemvelo's parks. It is probably the most well-known park in KwaZulu-Natal and one of the few big five parks, but the revenues are still not enough to cover all the running costs. On the other hand, Tembe Elephant Park is generating very little revenue even though it is known for the presence of these charismatic species. This is the case even though the big five species have been identified as an important pull factor for international tourists in Africa (De Vos et al., 2016, Lindsey et al., 2007). However, foreign tourists accounted for only 48% of the total tourism revenues and over half of the tourism revenues in 2015 came from domestic tourism in South Africa (African

Leadership University School of Wildlife Conservation, 2020). The result regarding the surprising low influence of the presence of Big Five species on the tourism revenues may be partly explained by the differences in preferences between domestic visitors and experienced travellers to protected and conserved areas in South Africa, as domestic visitors and experienced travellers are less interested in the charismatic species such as the Big Five (Lindsey et al., 2007). De Vos et al. (2016) also concluded that ecological attributes alone are not sufficient to explain variation in tourism numbers, but together with accessibility and affordability measures may provide quite good estimates.

Another important factor that increases running costs is poaching. Especially rhinoceros are targets for poachers in South Africa and maintaining antipoaching units and related equipment is costly (Di Minin et al., 2015).

On the revenue side, the COVID-19 pandemic has had clear and devastating consequences to conservation. Stagnated tourism sectors and restrictions aimed to control the spreading of the disease have led to a collapse of revenues for all protected and conserved areas which have had tourism revenue as an important funding source. Because of the higher running costs and net income sensitivity to changes in costs and revenues, protected areas with the big five species are in a more vulnerable position in the face of disturbances, such as the pandemic. Many of the running costs are fixed and not adjustable to changes in visitation numbers. Fixed costs include, for example, salaries for permanent staff, maintenance of the park (fences, roads, buildings) and game (feeding and veterinary costs, antipoaching units). At the beginning of the pandemic, there were concerns of increasing poaching activities due to the COVID-19 pandemic and related economic pressures on individuals and households (Lindsey et al., 2020). Luckily so far, the poaching statistics at least for rhinoceros in South Africa have decreased, probably because of the higher risk of getting caught while the country was in lockdown and the decrease in opportunities for illegal wildlife product trade (Save the Rhino International, 2021). However, increasing poaching and illegal wildlife trade has been reported elsewhere, in Kenya, Uganda and Brazil (T. Cumming et al., 2021).

6.4 The economic resilience of different types of protected areas

In this chapter, I discuss the likely economic resilience of different types of protected and conserved areas based on the economic analysis and resilience theory. I use the diversity of income sources, adaptive capacity, and capability to self-organize as aspects of resilience. These aspects stem from ecological and economic resilience theory which is explained in chapter 2.2.

The diversity of revenue sources is one aspect of the economic resilience of protected and conserved areas. Multiple revenues sources are expected to increase resilience by reducing dependency over a single revenue source. For public protected areas the funding sources consist of external funding, tourism revenues, and selling of game, plants and other products. Ezemvelo allows hunting in specific hunting areas but revenues from hunting were very marginal at least during the financial year 2019-2020. SANParks also facilitate private operators, getting concession fees from them on top of other revenues.

Based on the Table 4 including visitor statistics of Ezemvelo’s protected areas, visitor numbers and related tourism revenue do not have a clear, positive impact on net income, despite that being expected. Instead, the protected areas which have most tourism revenues also have the biggest net losses. Organisation-level comparison between Ezemvelo and SANParks again revealed, that most of SANParks’ organisation-wide budget bases on tourism revenues. Tourism revenues again are prone to different kinds of socio-economic or ecological disturbances, including epidemics among people (T. Cumming et al., 2021; Gössling et al., 2020; Lindsey et al., 2020) or wildlife (de Vos et al., 2016), financial recession (Gössling et al., 2020), legislation changes (such as allowing or denying hunting, see Di Minin et al., 2016) or natural disasters (such as wildfires or droughts, see for example Kurleto, 2020). Areas that are making extensive losses despite generating the most tourism revenues are potentially in an especially vulnerable position when it comes to economic resilience.

There are also protected areas that do not generate any revenue. These are managed by organisations that get their management funds from elsewhere: it can be governmental funding or revenues generated within another protected or conserved area. For example, SANParks generate 75% of their funding independently but only a few parks make a profit, which is then used in other areas (South African National Parks, 2021). Indeed, the resilience of a publicly managed park will eventually depend on the resilience of the whole system. This is why I compared the system-level differences between Ezemvelo and SANParks.

On the other end of the spectrum in terms of reliance on external funds are informal private conservation areas, such as the private game reserves in this study, which run independently and without any financial incentives provided by governments. All money needed to manage the area is generated in the conservation area or alternatively funded partially by the landowners. The diversity of revenue sources, therefore, depends on whether the owner combines multiple strategies and land uses in their property. Private conserved areas generally have more variety in revenue sources than state parks since some of them also do hunting, more game and venison sales and have livestock, which state entities typically do not do. Although the private game reserves in this study were on average more financially viable than the public parks, their vulnerability lies in the lack of a larger system behind them.

Lindsey et al. (2020) propose that the funding sources of protected and conserved could be diversified through the diversification of revenue streams from wildlife-friendly land uses, such as livestock co-management, sustainable consumptive use of wildlife (game meat and trophy hunting), international and domestic tourism. Secondly, they propose that domestic and international funding should be increased, for example through endowments, different kinds of financial instruments (such as REDD+), management partnerships and ecosystem service payments (Lindsey et al., 2020).

The second aspect of resilience is the system's capability to self-organise, innovate and make beneficial use of networks. The lack of a "system" that would fund a private conservation area if necessary likely reduces the economic resilience of private conservation areas. However, some private conservation areas have joint management systems with other private conserved areas within a larger conservancy, which saves management efforts for example through shared fencing (Mwakiwa et al., 2016). To some extent, joint-governance is also taking place across different types of protected and conserved areas (private, state, provincial and or community managed) which together create a larger network of conserved land, such as the Greater Kruger National Park (Chidakel et al., 2020). Although Chidakel et al. (2020) judge that the joint-management system is still underdeveloped in the Greater Kruger area, the network of protected and conserved areas could benefit from enhanced joint governance and the institutionalization of economic monitoring. The shared information and innovation spreading through networks could increase the resilience of system parts: the individual protected and conserved areas.

In some cases, it may be beneficial not to belong into a larger system, in the sense of economic resilience. For example, private conserved or protected areas are not dependent on the political changes related to the willingness of the government to fund conservation. Private informal conservation areas are not obligated to strict legislation and therefore may have higher possibilities to be innovative, which increases resilience. In the sense of the second aspect to resilience, the capability to self-organisation, private game reserves may be more resilient than public protected areas. However, the management objectives of informal conservation areas vary, which may affect resilience. Private conservation areas which target high-end customers may have high revenues but also high running costs. These parks have lower resilience towards changes in tourism numbers than those conservation areas which also attract local visitors and have more diverse funding strategies. Also, some other legislation changes may affect the resilience of private conserved or protected areas, such as restrictions or hunting bans (Di Minin et al., 2016).

The third aspect of resilience is adaptive capacity. High fixed running costs make protected and conserved areas more dependent on high cash input. Based on the data, parks managed by SANParks had the highest absolute running costs and parks managed by Ezemvelo had the highest size-relative running costs. Employee related costs accounted for over two-thirds of the total organisation-wide running costs for Ezemvelo, which could indicate Ezemvelo’s important role as an employer but also its vulnerability towards possible decreases in budget. As the proportion of fixed costs is larger, the running costs are less adaptive to changes in budgets. However, public protected areas are more likely to earn additional external financial help from the government or even abroad in the face of a crisis, than private conservation areas.

The informality of private game reserves comes with the freedom to combine conservation and ecotourism with other land uses, and also the possibility to change land use and even discontinue conservation-compatible land uses. This opportunity increases the adaptivity of the property owner in face of changes but also lowers the threshold of giving up the "identity of a system" (G. S. Cumming & Allen, 2017), which in this case is conservation. In that sense, informal private protected areas are likely to be less resilient towards negative changes in their budget, if they are not prepared for them.

An additional aspect of resilience is how long the system can cope with changing circumstances. In the case of economic resilience of protected and conserved areas, this depends on whether they have sufficient funds in reserve. These reserves were not identifiable from the data.

6.5 Limitations of the analysis and future research ideas

The most notable limitations of the study relate to the differences in data sources between different types of protected and conserved areas, and unequal sample sizes. SANParks' data was retrieved from management plans where revenues and running costs were only estimated. Running costs were initially estimated based on a zero-budgeting approach, in a way that costs never exceed the budget. However, each management plan had also additional estimated costs which were seen necessary to carry out the aims of the plan but exceeded the budget. Including these additional estimated costs changed the net income of the reserves significantly. It may be that these costs are eventually cut if no extra funding is available. In that case, the net loss of protected areas managed by SANParks would not be as high. For private game reserves, the data was older and thus the costs and revenues were adjusted for inflation to make them more comparable. However, the trend of increasing tourism numbers (at least until 2019, South African National Parks, 2020b) is not taken into account in this adjustment.

The LHS-based Monte Carlo data simulation was an experimental part of this thesis. The underlying aim was to carry out a global sensitivity analysis to model the sensitivity of the budgets of different kinds of protected and conserved areas to possible changes in costs and/or revenues. This type of analysis could give an idea about which budget parts are the most important in determining the economic resilience of protected and conserved areas. This was something that was not finished within the time and length limits of this thesis but something that could be proposed for future study topics. Global simulation modelling based on longitudinal datasets of financial reports over time along with the visitation statistics and most important biophysical and infrastructural attributes provide excellent possibilities for novel research for the good of our planet. I also acknowledge a need for future research taking a more social approach with a focus on individual agencies and power dynamics related to protected and conserved areas and the sharing of costs, revenues and other benefits of conservation.

VII. Conclusions

This thesis aimed 1) to identify revenue and costs structures and their variation across protected and conserved areas and 2) to build a better understanding of the economic resilience and vulnerabilities of different types of protected and conserved areas. Based on quantitative analysis of financial data from protected and conserved areas in South Africa, I found out that there are significant differences in the cost-revenue structures and net incomes between protected and conserved areas of different types: private game reserves, state-owned national parks (SANParks) and provincial parks (Ezemvelo). The size category of the protected area affected the running costs per hectare for public protected areas. However, private game reserves have such variety in their management strategies, that the size does not significantly predict their net income per hectare. The running costs of public protected areas are large and tourism revenues are not adequate to cover the costs in the case of Ezemvelo, and they seldom do for SANParks. For Ezemvelo, the running costs per hectare are much larger than for private protected areas, probably because of more extensive ecological targets (and thus larger biodiversity management costs), and diverse social responsibilities and aims (e.g. providing public services, such as educational services and research).

In the context of this study it is important to acknowledge 1) the wider role of Ezemvelo and SANParks in society as public organisations with both social and ecological responsibilities and aims, 2) the non-monetary values of conservation areas and the quality of conservation action as opposed to simply profit and 3) the geographies of power and inequality around conservation issues. I used economic modelling and financial data to compare the profitability of conservation areas but from the perspective of long-term economic resilience and not from the perspective of maximising profit-making.

Based on the economic modelling and resilience theory, I conclude that private game reserves are generally more financially viable, but their vulnerability lies in the lack of a larger system behind them: a system that would help during difficult times and require and encourage a long-term commitment to conservation. The economic resilience of private game reserves depends on the diversity of different types of revenues sources, and the savings that the owner has in reserve. The resilience of public protected areas is more tied to the political atmosphere regarding conservation funding: self-generated revenues form only a part of the budgets of public protected areas. The magnitude of running costs is higher for public protected areas than private, and especially for Ezemvelo the proportion of fixed costs (permanent staff salaries etc.) is high, which lowers the economic resilience of Ezemvelo's protected areas. However, the network of protected areas builds resilience towards local disturbances, as money can be reallocated between protected areas within the system. Additional public funding is also more likely to be allocated to public protected areas than to private reserves in the face of regional or global crises, such as in the case of COVID-19. Because of the higher running costs and net income sensitivity to changes in costs and revenues, public protected areas with the big five species are in a more vulnerable position in the face of disturbances.

As part of the resilience discussion, it is important to understand the underlying assumptions behind any normative assessment of the results. Here I assume, that managing existing and establishing new conservation areas is a desirable target and operational conservation strategy. Thus, the resilience of conservation areas is positive for nature conservation. However, there are critiques on whether privately owned game reserves meet conservation targets if their main objectives are commercial. Some problematic features from nature conservation perspectives in these areas may include overstocking (exceeding the carrying capacity with too many animals, especially large herbivores), introducing new species to the area where they did not naturally occur, land degradation, and disturbances due to a large number of visitors (G. S. Cumming et al., 2015). These issues stem from the trade-offs of combining conservation and business, which lead to follow-up questions: What is eventually the relationship between favourable cost-revenue ratio and the net conservation benefit? In which cases do the profit-seeking agenda and its negative environmental (and possible social) effects exceed the conservation benefit which could be reached with the extra money?

Another critique presented is how effective protected areas are in the end at resisting anthropogenic pressures. The success of a conservation area depends on adequate resources and management and it may even be more effective to have less but well-managed protected areas than more but poorly managed areas (see chapter 1.1., Geldmann et al. 2020). Whether the general funding of Ezemvelo and SANParks is adequate is another concern, which cannot be assessed based on this data. However, more and severe disturbances which affect the economics of protected areas can be expected in the future, fuelled by climate change, species decline and the increasing problematic encounters between humans and wildlife. This should be taken into account both in the system, and at the reserve level to increase the resilience of protected and conserved areas in the face of global changes.

Acknowledgements

First, I would like to thank all the members of the Helsinki Lab of Interdisciplinary Conservation Science (HELICS) for support, inspiration and expertise, and for creating a sense of belonging and community. Access to high-quality and detailed financial data from protected and conserved areas was only possible with the help and networks of my supervisors and the HELICS research group. The thesis was carried out in collaboration with Professor Rob Slotow at the University of KwaZulu-Natal in South Africa and the provincial conservation agency, Ezemvelo KZN Wildlife. The agency provided the main datasets used in the thesis. Special thanks go to Mike Msomi, who provided valuable help regarding the data and its interpretation. I also want to thank my friends and family for support and making sure I had life outside study and work. Last, but not least, I would like to express my gratitude to my supervisors Enrico Di Minin and Hayley Clements. Thank you for your excellent guidance, and for providing me with the opportunity for this learning journey!

References

Adams, V. M., Pressey, R. L., & Stoeckl, N. (2012). Estimating land and conservation management costs: The first step in designing a stewardship program for the Northern Territory. *Biological Conservation*, *148*(1), 44–53. https://doi.org/10.1016/j.biocon.2012.01.064

African Leadership University School of Wildlife Conservation (2020). *The State of the Wildlife Economy in South Africa. Country case study for the State of the Wildlife Economy in Africa report*.

Balmford, A., Gaston, K. J., Blyth, S., James, A., & Kapos, V. (2003). Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(3), 1046–1050. https://doi.org/10.1073/pnas.0236945100

Barreteau, O., D. Giband, M. Schoon, J. Cerceau, F. DeClerck, S. Ghiotti, T. James, V. Masterson, R. Mathevet, S. Rode, F. Ricci, & C. Therville. 2016. Bringing together social-ecological system and *territoire* concepts to explore nature-society dynamics. *Ecology and Society* 21(4):42. https://doi.org/10.5751/ES-08834-210442

Baum, J., Cumming, G. S., & De Vos, A. (2017). Understanding Spatial Variation in the Drivers of Nature-based Tourism and Their Influence on the Sustainability of Private Land Conservation. *Ecological Economics*, *140*, 225–234. https://doi.org/10.1016/j.ecolecon.2017.05.005

Biggs, R., Schlüter, M., Biggs, D., Bohensky, E. L., Burnsilver, S., Cundill, G., Dakos, V., Daw, T. M., Evans, L. S., Kotschy, K., Leitch, A. M., Meek, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M. D., Schoon, M. L., Schultz, L., & West, P. C. (2012). Toward principles for enhancing the resilience of ecosystem services. *Annual Review of Environment and Resources*, *37*, 421–448. https://doi.org/10.1146/annurev-environ-051211-123836

Bruner, A. G., Gullison, R. E., & Balmford, A. (2004). Financial costs and shortfalls of managing and expanding protected-area systems in developing countries. *BioScience*, *54*(12), 1119–1126. https://doi.org/10.1641/0006-3568(2004)054[1119:FCASOM]2.0.CO;2

Cadman, M. (2010). Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience. In *Africa* (Vol. 93). https://doi.org/10.1016/j.apmr.2011.08.012

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, *4*(8), 765–781. https://doi.org/10.1007/s10021-001-0045-9

Chidakel, A., Child, B., & Muyengwa, S. (2021). Evaluating the economics of park-tourism from the ground-up: Leakage, multiplier effects, and the enabling environment at South Luangwa National Park, Zambia. *Ecological Economics*, *182*(January), 106960. https://doi.org/10.1016/j.ecolecon.2021.106960

Chidakel, A., Eb, C., & Child, B. (2020). The comparative financial and economic performance of protected areas in the Greater Kruger National Park, South Africa: functional diversity and resilience in the socio-economics of a landscape-scale reserve network. *Journal of Sustainable Tourism*, *28*(8), 1100–

1119. https://doi.org/10.1080/09669582.2020.1723602

Child, B. A., Musengezi, J., Parent, G. D., & Child, G. F. T. (2012). The economics and institutional economics of wildlife on private land in Africa. *Pastoralism*, *2*(1), 1–32. https://doi.org/10.1186/2041-7136-2-18

Clements, H. S. (2016). *Multi-scale, social-ecological influences on private land conservation in South Africa*. University of Cape Town.

Clements, H. S., Baum, J., & Cumming, G. S. (2016). Money and motives: An organizational ecology perspective on private land conservation. *Biological Conservation*, *197*, 108–115. https://doi.org/10.1016/j.biocon.2016.03.002

Clements, H. S., Biggs, R., & Cumming, G. S. (2020). Cross-scale and social-ecological changes constitute main threats to private land conservation in South Africa. *Journal of Environmental Management*, *274*(November 2019), 111235. https://doi.org/10.1016/j.jenvman.2020.111235

Cortés-Capano, G. (2021*). Private land conservation policies: navigating from global gaps to local perceptions and needs*. Doctoral Dissertation (University of Helsinki).

Cumming, G. S., & Allen, C. R. (2017). Protected areas as social-ecological systems: Perspectives from resilience and social-ecological systems theory. *Ecological Applications*, *27*(6), 1709–1717. https://doi.org/10.1002/eap.1584

Cumming, G. S., Allen, C. R., Ban, N. C., Biggs, D., Biggs, H. C., Cumming, D. H. M., De Vos, A., Epstein, G., Etienne, M., Maciejewski, K., Mathevet, R. L., Moore, C., Nenadovic, M., & Schoon, M. (2015). Understanding protected area resilience: A multi-scale, social-ecological approach. *Ecological Applications*, *25*(2), 299–319. https://doi.org/10.1890/13-2113.1

Cumming, T., Seidl, A., Emerton, L., Spenceley, A., Kroner, R. G., Uwineza, Y., & van Zyl, H. (2021). Building sustainable finance for resilient protected and conserved areas: Lessons from COVID-19. *Parks*, *27*(Special Issue), 149–160. https://doi.org/10.2305/IUCN.CH.2021.PARKS-27-SITC.en

De Vos, A., Clements, H. S., Biggs, D., & Cumming, G. S. (2019). The dynamics of proclaimed privately protected areas in South Africa over 83 years. *Conservation Letters*, *12*(6). https://doi.org/10.1111/conl.12644

De Vos, A., Cumming, G. S., Cumming, D. H. M., Ament, J. M., Baum, J., Clements, H. S., Grewar, J. D., Maciejewski, K., & Moore, C. (2016). Pathogens, disease, and the social-ecological resilience of protected areas. *Ecology and Society*, *21*(1). https://doi.org/10.5751/ES-07984-210120

De Vos, A., Cumming, G. S., Moore, C. A., Maciejewski, K., & Duckworth, G. (2016). The relevance of spatial variation in ecotourism attributes for the economic sustainability of protected areas. *Ecosphere*, *7*(2), 1–19. https://doi.org/10.1002/ecs2.1207

Dietrich, J., Baudin, M, Christopoulou, M, Collette, Y. / Martinez, J. (2017). pyDOE [Python package]. Retrieved from https://pythonhosted.org/pyDOE/

Di Minin, E., Correia, R. A., & Toivonen, T. (2021). Conservation geography. *Trends in Ecology & Evolution*, *xx*(xx), 1–11. https://doi.org/10.1016/j.tree.2021.08.009

Di Minin, E., Fraser, I., Slotow, R., & Macmillan, D. C. (2013). Understanding heterogeneous preference of tourists for big game species: Implications for conservation and management. *Animal Conservation*, *16*(3), 249–258. https://doi.org/10.1111/j.1469-1795.2012.00595.x

Di Minin, E., Laitila, J., Montesino-Pouzols, F., Leader-Williams, N., Slotow, R., Goodman, P. S., Conway, A. J., & Moilanen, A. (2015). Identification of policies for a sustainable legal trade in rhinoceros horn based on population projection and socioeconomic models. *Conservation Biology*, *29*(2), 545–555. https://doi.org/10.1111/cobi.12412

Di Minin, E., Leader-Williams, N., & Bradshaw, C. J. A. (2016). Banning Trophy Hunting Will Exacerbate Biodiversity Loss. *Trends in Ecology and Evolution*, *31*(2), 99–102. https://doi.org/10.1016/j.tree.2015.12.006

Di Minin, E., & Toivonen, T. (2015). Global protected area expansion: creating more than paper parks. *BioScience*, *65*(7), 637-638

Dixon, J. A., & Sherman, P. B. (1991). Economics of Protected Area. *Journal of Agricultural Economics*, *20*(2), 68–74. https://www.jstor.org/stable/4313779

Drechsler, M., Eppink, F. V., & Wätzold, F. (2011). Does proactive biodiversity conservation save costs? *Biodiversity and Conservation*, *20*(5), 1045–1055. https://doi.org/10.1007/s10531-011-0013-4

Emerton, L., Bishop, J., & Thomas, L. (2006). Sustainable financing of protected areas: a global review of challenges and options. In *Best Practice Protected Area Guidelines Series* (Issue 13). The World Conservation Union (IUCN). https://doi.org/10.2305/iucn.ch.2005.pag.13.en

Ezemvelo KZN wildlife (2020). Financial report, occupation and visitor data. [unpublished excel statistics]

Fischer, J., Brosi, B., Daily, G. C., Ehrlich, P. R., Goldman, R., Goldstein, J., Lindenmayer, D. B., Manning, A. D., Mooney, H. A., Pejchar, L., Ranganaathan, J. & Tallis, H. (2008). Should agricultural policies encourage land sparing or wildlife-friendly farming?. *Frontiers in Ecology and the Environment*, *6*(7), 380-385.

Frank, L. G., Woodroffe, R., & Ogada, M. O. (2005). People and predators in Laikipia District, Kenya. In R. Woodroffe, S. Thirgood, & A. Rabinowitz (Eds.), *People and Wildlife* (pp. 286–304). Cambridge University Press. https://doi.org/10.1017/CBO9780511614774.019

Frazee, S. R., Cowling, R. M., Pressey, R. L., Turpie, J. K., & Lindenberg, N. (2003). Estimating the costs of conserving a biodiversity hotspot: A case-study of the Cape Floristic Region, South Africa. *Biological Conservation*, *112*(1–2), 275–290. https://doi.org/10.1016/S0006-3207(02)00400-7

Geldmann, J., Manica, A., Burgess, N. D., Coad, L., & Balmford, A. (2020). A global-level assessment of the effectiveness of protected areas at resisting anthropogenic pressures. *Proceedings of the National Academy of Sciences*, *117*(41), 25945–25945. https://doi.org/10.1073/pnas.2018968117

Gössling, S., Scott, D., & Hall, C. M. (2020). Pandemics, tourism and global change: a rapid assessment of COVID-19. *Journal of Sustainable Tourism*, *29*(1), 1–20. https://doi.org/10.1080/09669582.2020.1758708

Hausmann, A, Slotow, R., Fraser, I., & Minin, E. Di. (2017). Ecotourism marketing alternative to charismatic megafauna can also support biodiversity conservation. *Animal Conservation*, *20*(1), 91–100. https://doi.org/10.1111/acv.12292

Hausmann, Anna, Slotow, R., Burns, J. K., & Di Minin, E. (2016). The ecosystem service of sense of place: Benefits for human well-being and biodiversity conservation. *Environmental Conservation*, *43*(2), 117–127. https://doi.org/10.1017/S0376892915000314

Hausmann, Anna, Toivonen, T., Slotow, R., Tenkanen, H., Moilanen, A., Heikinheimo, V., & Di Minin, E. (2018). Social Media Data Can Be Used to Understand Tourists' Preferences for Nature-Based Experiences in Protected Areas. *Conservation Letters*, *11*(1), 1–10. https://doi.org/10.1111/conl.12343

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), 1-23.

Johnson, J. E., Welch, D. J., Maynard, J. A., Bell, J. D., Pecl, G., Robins, J., & Saunders, T. (2016). Assessing and reducing vulnerability to climate change: Moving from theory to practical decision-support. *Marine Policy*, *74*(July), 220–229. https://doi.org/10.1016/j.marpol.2016.09.024

Kurikka, H. (2021). Globaali talouskriisi ja Suomen alueiden resilienssi. *Terra*, *133*(1).

Kurleto, M. (2020). The impact of climate change on tourism in Australia: a case study relating to bushfires in Australia in 2019/2020. *Studia Periegetica*, *2(30)*.

Lindsey, P. A., Alexander, R., Mills, M. G. L., Romañach, S., & Woodroffe, R. (2007). Wildlife viewing preferences of visitors to protected areas in South Africa: Implications for the role of ecotourism in conservation. *Journal of Ecotourism*, *6*(1), 19–33. https://doi.org/10.2167/joe133.0

Lindsey, P. A., Allan, J., Brehony, P., Dickman, A., Robson, A., Begg, C., Bhammar, H., Blanken, L., Breuer, T., Fitzgerald, K., Flyman, M., Gandiwa, P., Giva, N., Kaelo, D., Nampindo, S., Nyambe, N., Steiner, K., Parker, A., Roe, D., … Tyrrell, P. (2020). Conserving Africa's wildlife and wildlands through the COVID-19 crisis and beyond. *Nature Ecology and Evolution*, *4*(10), 1300–1310. https://doi.org/10.1038/s41559-020-1275-6

Lindsey, P., Baghai, M., Bigurube, G., Cunliffe, S., Dickman, A., Fitzgerald, K., Flyman, M., Gandiwa, P., Kumchedwa, B., Madope, A., Morjan, M., Parker, A., Steiner, K., Tumenta, P., Uiseb, K. & Robson, A. (2021). Attracting investment for Africa's protected areas by creating enabling environments for collaborative management partnerships. *Biological Conservation*, *255*, 108979.

Mace, G. M. (2014). Whose conservation? *Science*, *345*(6204), 1558-1560.

Mackenzie, C. A. (2012). Accruing benefit or loss from a protected area: Location matters. *Ecological Economics*, *76*, 119–129. https://doi.org/10.1016/j.ecolecon.2012.02.013

Martin, R., & Sunley, P. (2015). On the notion of regional economic resilience: Conceptualization and explanation. *Journal of Economic Geography*, *15*(1), 1–42. https://doi.org/10.1093/jeg/lbu015

Mascia, M. B., & Pailler, S. (2011). Protected area downgrading, downsizing, and degazettement (PADDD) and its conservation implications. *Conservation Letters*, *4*(1), 9–20. https://doi.org/10.1111/j.1755-263X.2010.00147.x

McCarthy, D. P., Donald, P. F., Scharlemann, J. P. W., Buchanan, G. M., Balmford, A., Green, J. M. H., Bennun, L. A., Burgess, N. D., Fishpool, L. D. C., Garnett, S. T., Leonard, D. L., Maloney, R. F., Morling, P., Schaefer, H. M., Symes, A., Wiedenfeld, D. A., & Butchart, S. H. M. (2012). Financial costs of meeting global biodiversity conservation targets: Current spending and unmet needs. *Science*, *338*(6109), 946–949. https://doi.org/10.1126/science.1229803

Moore, J., Balmford, A., Allnutt, T., & Burgess, N. (2004). Integrating costs into conservation planning across Africa. *Biological Conservation*, *117*(3), 343–350. https://doi.org/10.1016/j.biocon.2003.12.013

Mwakiwa, E., Hearne, J. W., Stigter, J. D., De Boer, W. F., Henley, M., Slotow, R., Van Langevelde, F., Peel, M., Grant, C. C., & Prins, H. H. T. (2016). Optimization of net returns from wildlife consumptive and non-consumptive uses by game reserve management. *Environmental Conservation*, *43*(2), 128–139. https://doi.org/10.1017/S0376892915000296

Naidoo, R., Balmford, A., Ferraro, P. J., Polasky, S., Ricketts, T. H., & Rouget, M. (2006). Integrating economic costs into conservation planning. *Trends in Ecology and Evolution*, *21*(12), 681–687. https://doi.org/10.1016/j.tree.2006.10.003

Naidoo, R., & Ricketts, T. H. (2006). Mapping the economic costs and benefits of conservation. *PLoS Biology*, *4*(11), 2153–2164. https://doi.org/10.1371/journal.pbio.0040360

Neuvonen, M., Pouta, E., Puustinen, J., & Sievänen, T. (2010). Visits to national parks: Effects of park characteristics and spatial demand. *Journal for Nature Conservation*, *18*(3), 224-229.

Niesten, E., Zurita, P., & Banks, S. (2010). Conservation agreements as a tool to generate direct incentives for biodiversity conservation. *Biodiversity*, *11*(1–2), 5–8. https://doi.org/10.1080/14888386.2010.9712639

OECD (2021). *Consumer price indices (CPIs) - Complete database*. Retrieved from https://stats.oecd.org

O'Sullivan, D., Bergmann, L., & Thatcher, J. E. (2018). Spatiality, maps, and mathematics in critical human geography: Toward a repetition with difference. *The Professional Geographer*, *70*(1), 129-139.

Packer, C., Loveridge, A., Canney, S., Caro, T., Garnett, S. T., Pfeifer, M., Zander, K., Swanson, A., MacNulty D., Balme, G., Bauer, H., Begg, C., Begg, K., Bhalla, S., Bissett, C., Bodasing, T., Brink, H., Burger, A., Burton, A., … & Polasky, S. (2013). Conserving large carnivores: dollars and fence. *Ecology letters*, *16*(5), 635-641.

Palomo, I., Montes, C., Martín-López, B., González, J. A., García-Llorente, M., Alcorlo, P., & Mora, M. R. G. (2014). Incorporating the social-ecological approach in protected areas in the anthropocene. *BioScience*, *64*(3), 181–191. https://doi.org/10.1093/biosci/bit033

Python Software Foundation (2018). Python Language Reference, version 3.7. Available at https://www.python.org/

QGIS Development Team (2020). QGIS Geographic Information System. Open Source Geospatial Foundation Project. Available at http://qgis.osgeo.org".

R Core Team. 2020. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Available at https://www.R-project.org/

Save the Rhino International (2021). The latest poaching numbers from South Africa.

Retrieved from https://www.savetherhino.org/rhino-info/poaching-stats/

South African National Biodiversity. (2017). *The business case for biodiversity stewardship*.

South African National Parks (2020a). *South African National Parks Annual Report 2019/20*. Retrieved from https://www.sanparks.org/assets/docs/general/annual-report-2020.pdf

South African National Parks (2020b). Tourism summary. [unpublished excel statistics] link to where you got these?

South African National Parks (2021). Approved plans. Retrieved from https://www.sanparks.org/conservation/park_man/approved_plans.php

Taylor, A., Lindsey, P. A., Davies-Mostert, H., & Goodman, P. (2016). An assessment of the economic, social and conservation value of the wildlife ranching industry and its potential to support the green economy in South Africa. *The Endangered Wildlife Trust, Johannesburg*, 96-109.)

Taylor, W. A., Lindsey, P. A., Nicholson, S. K., Relton, C., & Davies-Mostert, H. T. (2020). Jobs, game meat and profits: The benefits of wildlife ranching on marginal lands in South Africa. *Biological Conservation*, *245*(April), 108561. https://doi.org/10.1016/j.biocon.2020.108561

The Department of Environmental Affairs of Republic of South Africa (2020). *Protected areas register*. Retrieved from https://egis.environment.gov.za/protected_areas_register

Van Rossum, G., & Drake, F. L. (2009). *Python 3 Reference Manual*. Scotts Valley, CA: CreateSpace.

Versveld, D.B., Le Maitre, D.C., Chapman, R.A., 1998. *Alien Invading Plants and Water Resources in South Africa: A Preliminary Assessment*. CSIR: Environmentek, Stellenbosch

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature*, *515*(7525), 67–73. https://doi.org/10.1038/nature13947

Xun, X., & Yuan, Y. (2020). Research on the urban resilience evaluation with hybrid multiple attribute TOPSIS method: an example in China. *Natural Hazards*, *103*(1), 557–577. https://doi.org/10.1007/s11069-020-04000-0

Appendices

Appendix 1. From site-level to park-level data (Ezemvelo)

The process of allocating costs and revenues indicated at site level into park level costs in Ezemvelo's financial report is presented in the table below. All protected areas and sites in the Ukhahlamba Drakensberg Park World Heritage site were grouped as one park and similarly all sites within iSimangaliso Wetland park, including uMkhuze Game reserve, were grouped together. Marine protected areas (including the marine areas of iSimangaliso) were excluded from the analysis.

Park name	Sites within park
Amatikulu Nature Reserve	Amatikulu Nature Res, Amatikulu Profit
Chelmsford Nature Reserve	Chelmsford Camp, Chelmsford NR, iNcandu & Richgate
Enseleni Nature Reserve	Enseleni Nature Res
Harold Johnson Nature Reserve	Harold Johnson Nature Reserve
Hluhluwe-Imfolozi Park	Hilltop, Mpila Hluhluwe Game Reserve Hluhluwe Research Centre, Hluhluwe Workshop iMfolozi Game Reserve iMfolozi Trails, iMfolozi Workshop Investigations HiP Nselweni Bush Lodge Park Manager HiP Partnerships & Human Wildlife Conflict HIP
iSimangaliso Wetland Park	Cape Vidal, Charters Creek False Bay Camp, False Bay Cost Fani's Island iSimangaliso Law Enforcement & Prosecutions Manager Kosi Bay, Kosi Bay Cost Lake Sibaya, Mantuma Manzengwenya Maphelana, Maphelana Reserve Mfabeni (Eastern Shores), Ozabeni Park Ecologist iSimangaliso Park Manager Isimangaliso Santa Lucia Sodwana Bay Resort Sodwana Bay Workshop St Lucia Conservation St Lucia Crocodile Centre St Lucia Estuary St Lucia/ Heavy Plant Workshop St. Lucia Estuary Conservation Umkhuze Controlled Hunting Area Umkhuze Game Reserve Western Shores
Itala Nature Reserve	Ithala Controlled Hunting Area Ithala Reserve Ntshondwe
Kenneth Stainbank Nature Reserve	Kenneth Stainbank Nature Reserve
Krantzkloof Nature Reserve	Krantzkloof Nature Res
Midmar Nature Reserve	Midmar Camp Midmar Nature Reserve Midmar Training Centre

	Midmar Workshop
Mount Currie Nature Reserve	Mount Currie Reserve & CD
Mpenjati Nature Reserve	Mpenjati Nature Reserve
Ndumu Game Reserve	Ndumo Camp Ndumo Cons
Nsikeni Nature Reserve	Ntinini Conservation
Ntinini Nature Reserve	Ntsikeni
Oribi Gorge Nature Reserve	Oribi Gorge Oribi Gorge Conservation
Spioenkop Public Resort Nature Reserve	Spioenkop Spioenkop Conservation
Tembe and Sileza Nature Reserve	Tembe/Sileza
Ukhahlamba Drakensberg Park	Cathedral Peak Conservation Cobham Didima, Didima Campsite Garden Castle, Giants Castle Highmoor, Hillside Injesuthi Camp, Injesuthi Conservation Kamberg Camp, Kamberg Conservation Lotheni Camp, Lotheni Conservation Maluti Drakensberg Transfrontier Project Monks Cowl Camp, Monks Cowl Conservation RNNP Mahai Camp Royal Natal Conservation Rugged Glen Conservation Rugged Glen Stables Thendele, Umkhomazi Vergelegen, Witteberg
Umlalazi Nature Reserve	Umlalazi
Umtamvuna Nature Reserve	Umthamvuna Nature Res
Vernon Crookes Nature Reserve	Vernon Crookes Nature Res
Wagendrift Public Resort Nature Reserve	Wagendrift, Wagendrift Conservation
Weenen Nature Reserve	Weenen